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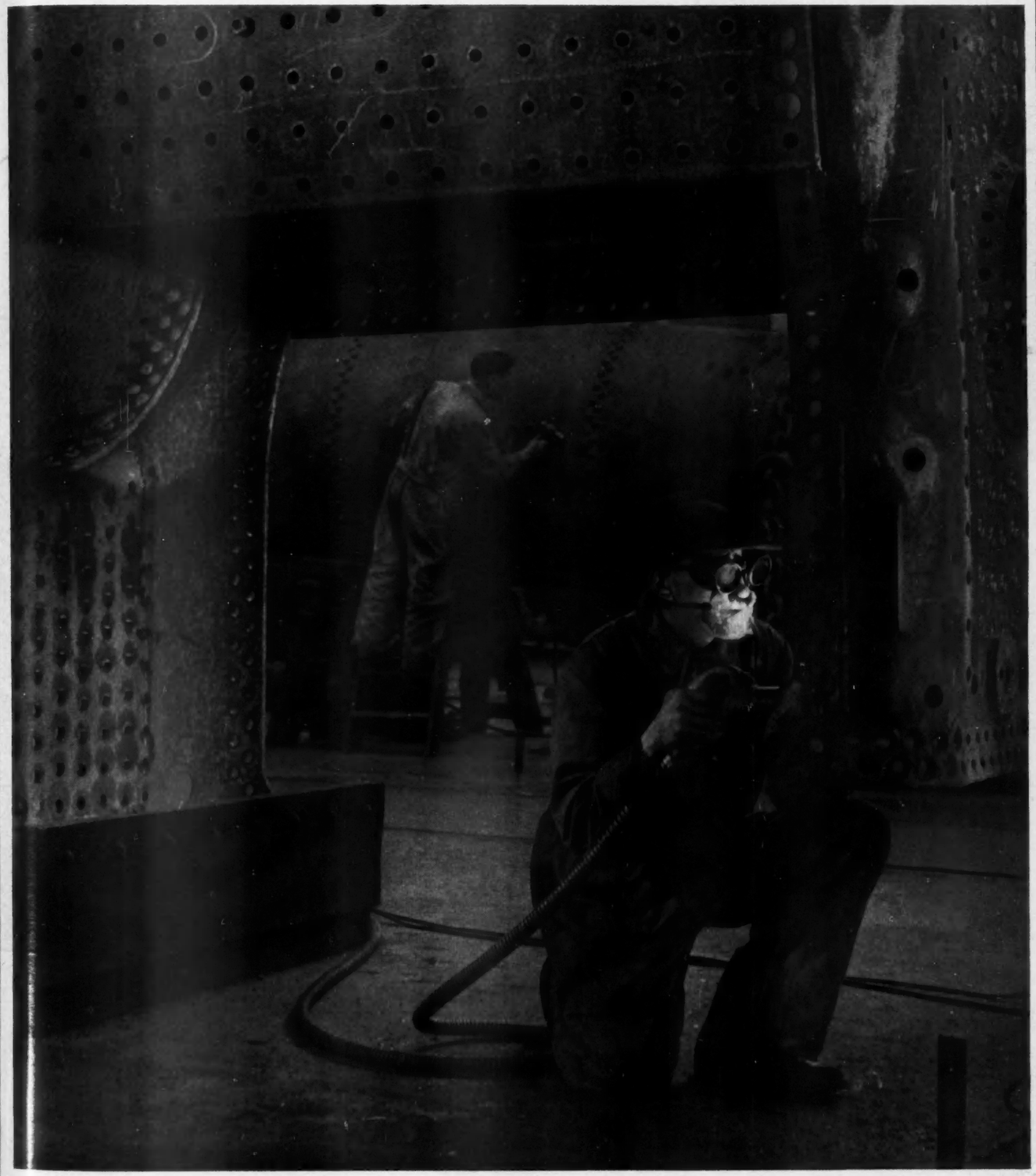

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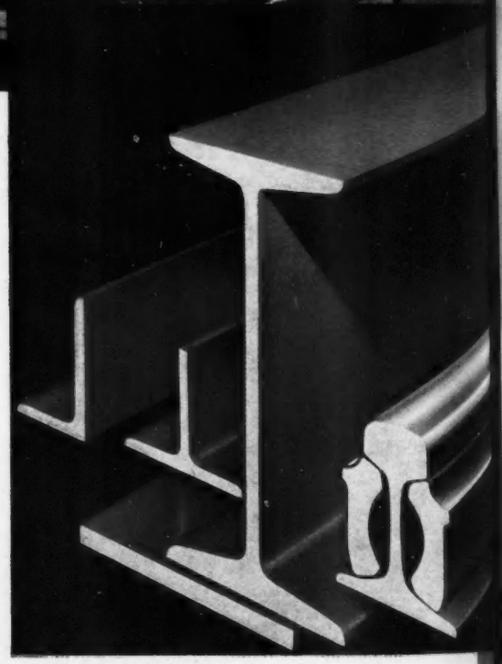

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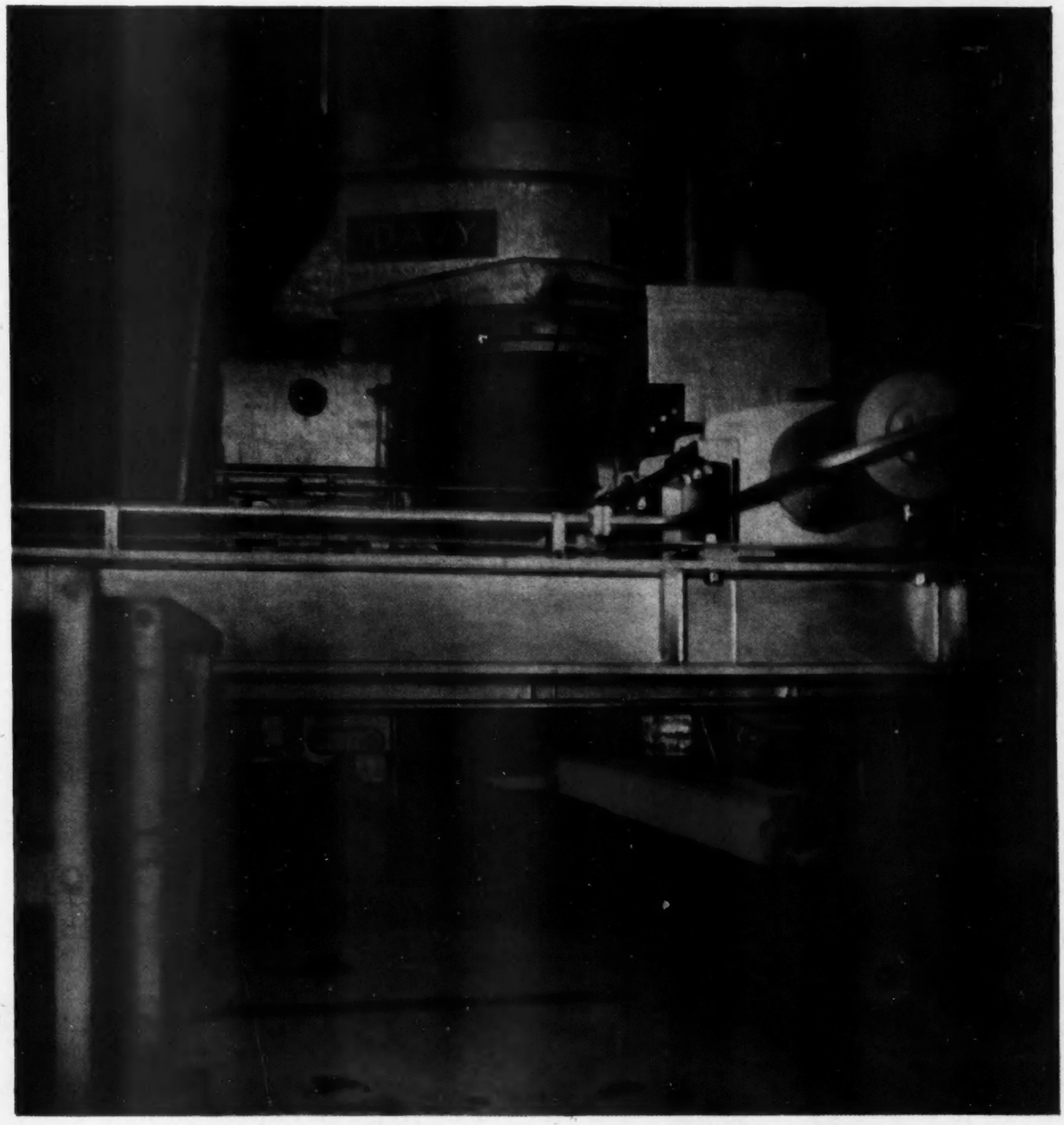

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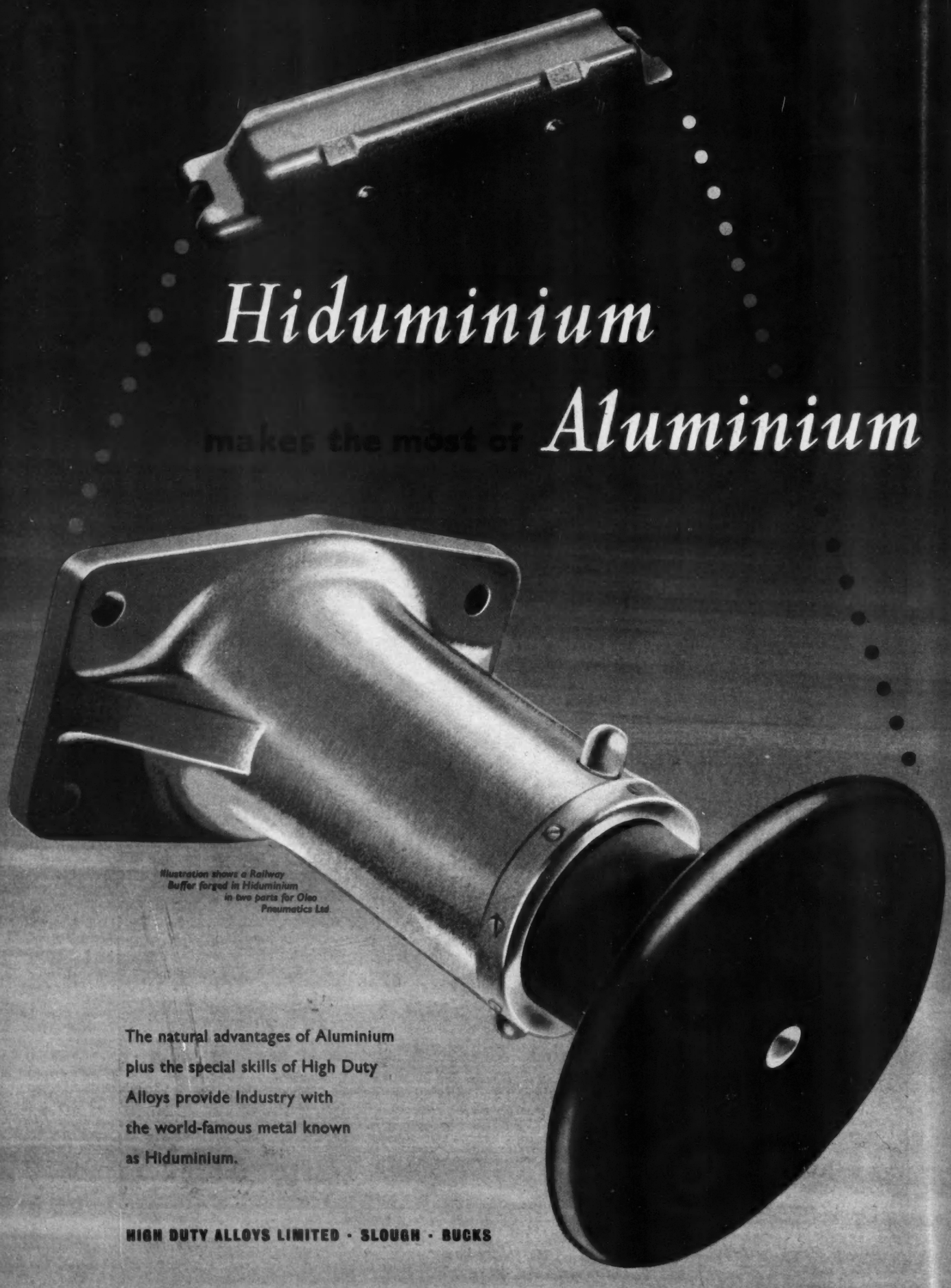

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ENGINEERING

An Illustrated Weekly Journal

Vol. 179 No. 4649 MARCH 4, 1955

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EXPORTS FOLLOW THE EXPERTS

"WITH a view to the creation of stability and well-being which are necessary for peaceful and friendly relations between nations . . . the United Nations shall promote higher standards of living, full employment, and conditions of economic and social progress and development; solutions of international economic, social, health and related problems . . ." So runs Article 55 of the United Nations Charter. One of the ways in which the United Nations can promote higher standards of living is to raise the standards in backward or poor countries, by helping them to increase their exports to pay for more imports. Part of the imports are capital goods which go to increase the production of exports, and providing there remains a world demand for the exports, which are generally raw materials, there is nothing to stop the prosperity and living amenities of the countries improving.

But at the beginning there is the difficulty of knowing how to start, or how to increase, the production of raw materials for export. If, for example, coal is known to be available in an under-developed country, but there are no experts who can tell whether the coal can be mined and exported economically, where can the Government of the country turn for advice? The technical assistance agencies of the United Nations serve this purpose. These agencies include some which have been set up by the United Nations and some which existed before, and between them they cover, in theory at least, a field as wide as human knowledge.

There are ten agencies, giving technical assistance in varying fields, such as agriculture, civil aviation, and health. The most interesting to the engineer is the Technical Assistance Administration (T.A.A.). It covers anything not covered by the other agencies, but its largest single field of activity is industrial development. The structure of the agencies is clearly set out in a booklet which gives a report of visits to the T.A.A. in New York, and to the Food and Agriculture Organisation in Rome, by teams from the Federation of British Industries.*

One of the main functions of technical assistance in the post-war world is the fostering of managerial ability and technical skills in the less developed areas of the world. In Britain there is a special understanding of the problem because Britain has been sending engineers and managers to the less developed parts of the Empire and elsewhere for many years. In all programmes of technical assistance, both those sponsored by this country now and in the past, and those sponsored by the United Nations now, assistance has been rendered to less developed countries principally by the following methods: by sending experts to give technical advice; by selecting men from receiving countries to be given training in industrialised countries; by providing on a small scale demonstration and training plant in the receiving countries.

In some cases the technical advice is followed up by financial assistance if major engineering or other works are recommended. If, for example, an under-developed country wants to build a dam or barrage to irrigate a waterless area, it is likely that they will need to borrow money. But it is most important that in the first instance they should have advice on whether the area concerned is suitable for irrigation, on the best place for the dam, and on what type of firms should be asked to estimate for the construction. To obtain the needed advice a country can apply to the United Nations—between a third and a half of all the communications reaching the United Nations in New York are concerned with technical assistance—who then inform suitable countries of the requirements and ask them to submit names of experts for selection. The F.B.I. report mentions that liaison between the United Nations and the United Kingdom is not always sufficient to ensure that all requests are known in this country, and that therefore in some cases the names of men eminently qualified for a particular job have not been put forward.

The advice from the technical assistance expert can initiate work which will have a profound effect on the country to which he gives it. Engineers have often planned and directed to completion projects which have had a lasting humanitarian and economic effect. Roads and railways have brought higher standards of living to remote places; dams have brought great areas of desert under cultivation. Many of the programmes of the T.A.A. follow in this tradition, and emphasise the immense power for good which can be developed by engineers. At the annual dinner of the Association of Consulting Engineers last week (reported on page 261), Mr. A. R. W. Low, Minister of State, Board of Trade, called for engineers—consulting engineers particularly—to take temporary appointments with United Nations and other organisations rendering technical assistance abroad. The old saying "Exports follow the flag" he amended to "Exports follow the experts." To serve abroad in this way is to serve two countries simultaneously; to give help where help is most needed; and to gain a reward that is not to be measured solely in pounds—or dollars.

* *United Nations Technical Assistance: Report by the Federation of British Industries.* 21 Tothill-Street, London, S.W.1. (2*s.* 9*d*).

Weekly Survey

Cover Picture: *The low efficiency of the steam locomotive is one of the chief reasons for giving up this form of railway traction. But the boiler should not be blamed—its thermal efficiency is high, though it requires regular washing out. The locomotive boiler has remained unchanged in essentials for almost the whole of railway history. It is a "classic" in the history of engineering. The man in the foreground of the cover picture is working on a firebox backplate.*

* * *

STEEL EXPANSION

The iron and steel industry plan an increase of 4·5 million ingot tons in output by 1958, to meet an expected increase in future home demand of 4½ per cent. per annum. Demand in 1958 is estimated at 22½ million tons, including 3 million tons for export; imports are only expected to reach 100,000 tons. These proposals have been given in a report, *Development of the Iron and Steel Industry, 1953 to 1958*, of which excerpts are given elsewhere in this issue. Most of the schemes for modernisation and expansion that have been approved have already been started, and Sir Archibald Forbes, Chairman of the Iron and Steel Board, commenting on the report said that the Board considered the 1958 target a "practicable level of output." An encouraging statement in the report, also quoted by Sir Archibald, was that the developments in progress comprise to a considerable extent the replacement of existing plant and will yield a further increase in productivity. He mentioned that since 1949 steel output had increased by 20 per cent., whereas the industry's employment was only 2 per cent. higher. The fact that the Board consider that the 1958 level of output can be reached with little or no increase in the number employed is good news at a time when the availability of labour is the principal check to increased industrial growth.

The omission of any reference to the erection of a new wide-strip mill suggests that this has been shelved for the moment at least. At the time the subject was being discussed (ENGINEERING, January 14), it was widely argued that the fast rising trend in the output of cars and consumer durable goods, as well as in cans for food packaging, would lift the demand for sheet and other light flat products far above the level of the industry's output. The sudden rise in the Bank Rate and the re-imposition of restrictions on hire purchase are likely to check the growth of demand for sheet-steel products unless exports can take full advantage of the increased income of primary producing countries and make up fully for the reduction in the rate of increase of home sales. As exports are unlikely to achieve this, the demand for sheet may fall fairly well in line with the steel industry's expectations, or even below them.

* * *

NEW TRENDS IN COMPRESSORS

Sales of air compressors, which in 1953 and the early months of 1954 had fallen off substantially, have now recovered, and the heavier programme of public works expenditure which is now to be undertaken in the United Kingdom will help to ensure that they continue at a high level. Nevertheless, since about 40 per cent. of the output is exported, much depends upon trends abroad. Mr. Harry S. Broom, M.I.Mech.E., chairman and joint managing director of Broom and Wade, Limited, in his annual statement last week, blamed import restrictions in several countries and, in particular, the closing of the South American market for a slight fall in turnover. However, he was happy to inform shareholders that sales had improved in the second half of the year, and that the order book is now satisfactory —although this did not mean "that orders are easy to come by: on the contrary, competition is keener and customers more price-conscious."

Broom and Wade are countering this partly by increasing advertising and partly by heavy capital expenditure to improve productivity. Like other compressor manufacturers, in the present period of rapid technological advance in compressor design, they are also faced with the necessity of undertaking heavy research and development expenditure. One notable trend is that towards larger standard compressor sizes; whereas formerly these were based on a compressed-air consumption of 50 to 55 c.f.m. per tool, there is now a tendency to use 60 to 65 c.f.m. Five British compressor manufacturers, including Broom and Wade, are known to be working on rotary compressors, which have been supplanting traditional reciprocating compressors in the United States. A small British rotary compressor has been on the market for some time, and Consolidated Pneumatic, who are to offer a range of from 125 to 600 c.f.m., exhibited a 365-c.f.m. model at the Public Works Exhibition last year. The era of the reciprocating compressor is, of course, by no means over, and not all engineers will be convinced that the rotary design has any outstanding advantage over the reciprocating. There are some who hold that the future lies with free-piston designs, such as the Pescara. The principle is not new, but intensive development over the past few years has overcome the technical difficulties which were encountered initially, and free-piston compressors are now being marketed successfully in the United Kingdom.

* * *

THE ENGLISH ELECTRIC COMPANY

The possibility of an increase in the capital of the English Electric Company, Limited, was mentioned in Weekly Survey for February 18. The directors of the company announced last week that if the offers to shareholders of the Vulcan Foundry, Limited, and their subsidiary Robert Stephenson and Hawthorns, Limited, are accepted all the authorised capital of the English Electric Company will have been issued with the exception of £947,715 in ordinary shares. They have therefore decided to increase the authorised capital from £15 million to £25 million by the creation of a further 10 million £1 ordinary shares. The report adds that no further issues are at present contemplated and it has been suggested that the additional capital may eventually be used for further acquisitions. The company's growth since the war is reflected in the increase in the authorised capital from £5 million in 1946, the last increase being from £10 million to £15 million in July, 1953.

Apart from steady expansion in the company's original fields of electrical and mechanical engineering, and in aircraft (a controlling interest in D. Napier and Son, Limited, was acquired in 1942) the company have since the war acquired substantially the whole of the issued capital of Marconi's Wireless Telegraph Company, Limited, and a majority interest in John Inglis and Company, Limited, of Toronto, manufacturers of heavy engineering equipment and of a range of consumer appliances. The company have for a long time had an important stake in the production of electric traction equipment and, if the acquisition of the Vulcan Foundry, Limited, is carried through, they will be in a strong position to benefit from the £1,200 million railway modernisation plan.

In the aircraft field further expansion is also to be expected. Besides producing the Canberra bomber, the company have received a pre-production order for their new fighter the P1, which is stated to be the first fighter capable of supersonic speed in level flight. Napier are endeavouring to build up an export trade for their Eland propeller-turbine engine. Other developments to which the company may be expected to make an important contribution include the nuclear power stations and the St. Lawrence Seaway and power development project. While still predominantly concerned with heavy engineering, they also have an important production of television receivers and domestic appliances.

* * *

INDUSTRY AND IMPORT PRICES

Much has been written of recent weeks on the way in which the price of imported goods is putting pressure on the pound abroad. It is interesting to note that, as far as can be judged from official statistics, the engineering industry's activities have so far made only a very limited contribution towards this problem. Since June last year the prices of imported foodstuffs have increased from 101 to 105 (taking 1954 as the base year) and the price of imported manufactured goods has gone up from 100 to 105. In contrast, the price index of basic materials has gone up only from 101 to 102, and imported fuel has remained unchanged.

On the side of exports, the price index of engineering goods has increased from 100 to 101. While, therefore, the ratio of import to export prices has worsened, from the point of view of this country paying its way, from 100 to 104 between June and January, the terms of trade for the engineering industry have remained almost unchanged.

* * *

BANK RATE AT 4½ PER CENT

The increase in Bank Rate from 3½ to 4½ per cent. came as a surprise last week. It was known that the Government were becoming slightly concerned about the pressure on sterling and the difficulty of maintaining a growing boom in consumer goods at a time of full employment if the sale of consumer goods were further stimulated by a large expansion in hire purchase facilities, but few had expected quite such a large increase. The increase in the rate, which has been imposed as a means of raising all interest rates including the price of accommodation for working capital from the banks, has been designed primarily to prevent the country trying to do too much when its resources are at full stretch. Too great a pressure on available supplies of manpower must mean inflation, rising costs and a weakening of the pound's value abroad. The step has also been taken to protect the capital investment programme which is scheduled for expansion in the next few years.

An immediate result has been the announcement of increased interest charges to be made by the Public Works Loan Board to local authorities. The rate on short loans of under five years is increased from 2¼ to 3⅛ per cent., but the most important change is that from 3¼ to 4 per cent. for loans longer than 15 years, as the greater part of money borrowed from the P.W.L.B. is taken for 40 to 60 years. The effect is likely to limit the efforts of local authorities to borrow through the gilt-edged markets until prices improve.

It is hoped that by preventing a too rapid expansion in consumer goods, there will be less difficulty in finding the men and materials for modernisation of equipment, increased factory space, higher capital outlay by the public utilities, modernisation of the railways and an ambitious road programme—all of which will be building up between 1955 and 1960. Thirty years ago an increase in Bank Rate would have been considered a very odd way of stimulating investment. Our fathers, or at least those of them who took an interest in such matters, would have associated a hardening of interest rates with general contraction of industry and possible unemployment. To-day, the somewhat more sophisticated view is taken that a deft use of Bank Rate in good times, accompanied in this case by hire purchase restrictions, can limit the rate of expansion in consumer goods and the rate at which companies accumulate stocks of material (since these will have to be financed out of dearer working capital) without impairing

industries making capital equipment. This is probably true, but small engineering concerns dependent on their banks for finance without enjoying the luxury of a sellers' market for their products in which prices can be raised, may find the Chancellor's prescription for innoculation against inflation hardly to their liking.

* * *

DAVID BROWN CORPORATION LTD.

Following the Massey-Harris Ferguson amalgamation a little over a year ago, the David Brown Corporation, Limited, who are the third largest producers of agricultural tractors in this country, have recently extended their range of agricultural machinery by the acquisition of a controlling interest in Harrison, McGregor and Guest, Limited. The Corporation claim that as a result they will become the only entirely British-owned manufacturer of a complete range of farm machinery covering wheeled and crawler tractors, tillage implements and harvesting equipment. The parent company were, of course, already large producers of agricultural machinery in addition to their interests in other fields of engineering, including gears and gear units, precision tools, steel and bronze castings, machine tools and Aston Martin and Lagonda cars.

Harrison, McGregor and Guest, Limited, have been established for 83 years; they have 514 employees and their present products include binders, mowers, drills, swath turners, manure spreaders and meal mixers. In view of the present high cost of new factory construction, one of the main advantages of the acquisition to the parent company will be the Albion factory at Leigh, Lancashire, which occupies 13½ acres in the centre of the town and has 426,000 sq. ft. of covered manufacturing space. David Brown propose to expand the range of products, particularly harvesting machinery, made at the Leigh works and to transfer there the manufacture of tillage implements at present produced at their Meltham factory, thus making available increased floor space for the production of David Brown tractors.

* * *

ENGINEERING AND HIRE PURCHASE

The article in this issue on the light electrical and cable industries reports outstanding prosperity during the past year for manufacturers of household appliances which constitute a large and growing section of electrical engineering. Their consumption of sheet steel, light castings, stampings and electric motors is now so large that any fluctuation in their output is likely to affect metal manufacturing and metal-using industries—and also plastics—to an extent that would not have been thought possible 20 years ago. The rising output of vacuum cleaners, washing machines, refrigerators, radio and television sets, electric irons, etc., was achieved despite the heavy incidence of purchase tax. The extensive use the community made of hire purchase facilities as soon as they were relaxed last July, shows that there is a very keen desire in the majority of households to mechanise the home, and to have both radio and television receivers. It was the sheer scale of this rush to buy that led to the re-imposition last week of restrictions on hire-purchase. At a time when the terms of trade are moving against Britain—we are having to pay more for our imports without being in a position, owing to foreign competition, to increase the prices of our exports—it is essential that we should increase the volume of our exports. In conditions of full employment this can only be done by reducing consumption at home.

The next year will thus mean less home sales and, everyone hopes, more exports, though this will not be achieved easily. The blunt truth is that those products the exports of which cannot be increased to take up the expected fall in home sales will register a fall in output, and thus release labour to industries with a large export potential. However unpalatable this may be to manufacturers of household appliances and to their suppliers—all of whom need a high level of output to keep costs to a minimum—it has come to stay for at least a full year, and possibly longer. This need to keep home consumption low also suggests that few, if any, reductions in purchase tax can be expected in the coming Budget.

If the immediate future is not so bright as seemed likely a few days ago, it is by no means bleak. The long term prospects of the industry are very good indeed: there are still vast sales potentials which must one day be realised.

* * *

SWITZERLAND

Swiss imports from the United Kingdom in 1953 represented only 7 per cent. of total Swiss imports, compared with 20 per cent. from Germany, 12 per cent. from the U.S.A., 10 per cent. from France and 9 per cent. from Italy. Most imports from the United Kingdom into Switzerland and vice versa are free from quantitative restrictions, and where restrictions are in force arrangements have recently been concluded regarding the level of the quotas for 1955.

In an economic survey of Switzerland* published last month, the Commercial Counsellor of the British Embassy in Berne expresses the view that while there is strong competition for trade in Switzerland, this market is in the long view one of the most valuable that any United Kingdom exporter can cultivate. The survey suggests ways in which British exporters can challenge foreign competitors in Switzerland and emphasises the importance of corresponding and sending attractive catalogues and price lists to the prospective buyer in his own language, using the metric system of measurement. It also emphasises the need for good wrapping and, where appropriate, for attractive packaging.

Although Switzerland provides quite an important market for the British engineering industry, in a number of fields Swiss engineering concerns are strong competitors. Engineering and watch-making accounted for about half of total Swiss exports over the three years 1951 to 1953, and in both fields exports reached new records in those years. The Swiss watch industry exports 95 per cent. of its production and over one-third of these exports normally go to the U.S.A. The industry was therefore seriously alarmed at the decision of the U.S. Government in May, 1954, to increase the duties on imported watches by 50 per cent.

Though the survey undoubtedly provides a very useful and comprehensive study of Swiss industry and the Swiss market for British products, it is unfortunate that seven months appear to have elapsed between the writing of the report and its publication, since the survey is dated July, 1954, and the latest statistics included refer to the first quarter of 1954.

* * *

IMPROVING LONDON TRANSPORT

The committee appointed by the Minister of Transport to inquire into the conduct of the undertakings operated by the London Transport Executive has now reported. Needfully, a large part of the report is concerned with the impact of road and rail operation on London's travelling public but scanning through the report the reader is continually impressed with the significance of the engineering contribution to the successful working of the Executive. The extent of this contribution, and the committee's comments upon the organisation and working of the engineering departments, are reported elsewhere in this issue.

* *Overseas Economic Surveys: Switzerland—Economic and Commercial Conditions in Switzerland.* Published for the Commerical Relations and Exports Department of the Board of Trade by H.M. Sationery Office. (4*s.* 6*d.* net)

In their consideration of the organisation of the Executive the committee are critical of the division of responsibility of the members of the Executive for the work of the departments. In particular, the committee note that the chief mechanical engineer (road services) reports to the member who is otherwise responsible for finance and who was formerly chief financial officer to the old London Passenger Transport Board. An appendix shows also that the chief electrical and the chief civil engineer and chief mechanical engineer (railways), together with the chief architect, report to the former solicitor to the Board; the director of research—the other chief officer concerned with matters of a technical nature—reports to the chairman. The committee criticised this arrangement from several points of view and the Executive defended it on the argument of collective responsibility by the several members.

Regrettably neither the committee nor the Executive apparently see the advantages that would accrue from the appointment of an engineer-in-chief, to whom all the technical departments would report, and who would be a member of the Executive. The criticism that no one engineer could be familiar with all the relevant branches of engineering is invalid, for he would be infinitely more valuable than several members with no knowledge of any branch of engineering. It is no defence by the Executive, nor for that matter by any other organisation or industrial company, that its decisions do not apparently depend upon points of engineering detail: no problem can be fairly examined without an awareness of the implications at all levels. London Transport should fall in line with the British Transport Commission, where the appointment of Mr. J. C. L. Train has done much to broaden the approach of the Commission and has significantly aided the promotion of the Commission's £1,200 scheme for modernisation of the main line railways.

* * *

STANDARDISATION TO SUIT THE USER

The standardisation of engineering equipment and consumable stores is of great importance to the user, whether he takes an active part in formulating the standards or passively accepts the standards when they have been formulated. The Engineering Equipment Users' Association, founded five years ago, promotes the interests in this field of those firms which are members of the Association. It does this, mainly but not wholly, through the British Standards Institution. In many cases it initiates specifications which are subsequently taken up by the B.S.I. Among the subjects it deals with are materials handling equipment, instruments, reduction gears, pumps, ball and roller bearings, storage tanks, heat exchangers, and various electrical engineering items.

Membership of the E.E.U.A. was recently extended to admit firms who wish to take advantage of the technical benefits of the Association's work without committing themselves to the same extent as full members in respect of expense and staff time. The full members are Albright and Wilson, Limited, Courtaulds Limited, Distillers Company, Limited, Dunlop Rubber Company, Limited, Imperial Chemical Industries, Limited, Monsanto Chemicals Limited, Shell Petroleum Company, Limited, and Unilever Limited. The new category of associate member is now represented by the National Coal Board, Metal Box Company, Limited, and the British Transport Commission. The primary qualification for full or associate membership is that the firm must be predominately users rather than manufacturers of engineering equipment. As users with common interests they are able to persuade manufacturers of the importance of their requirements. The Secretary of the Association is Brigadier L. F. S. Dawes and the offices are at 20 Grosvenor-gardens, London, S.W.1.

HYDRO-ELECTRIC PROGRESS IN SCOTLAND

The report* of the North of Scotland Hydro-Electric Board for 1954, which was published last week, shows that satisfactory progress is being made both as regards operation and construction. During the year, 1,566 million kilowatt-hours were generated by water, steam or Diesel oil, the first accounting for about 75·5 per cent. of the total. Some 75 per cent. of the output was consumed in the Board's own area, while the rest was sold to the British Electricity Authority in Central Scotland. The total compares with the 1,333 million kilowatt-hours which were generated in 1953. The maximum demand was 314,240 kW, an increase of 29,882 kW over that of the previous year. During the year 18,893 new consumers were connected, bringing the total up to 322,127. Of these, 3,334 were farmers, crofters or farm workers, and well over 40 per cent. of the farms and crofts in the Board's area now have an electricity supply.

There were 17 hydro-electric power stations in operation with a total capacity of 431,385 kW, of which 32,700 kW were brought into use during the year under review. In addition, 397,900 kW are under construction, six of the stations being wholly or partly underground; and 388,900 kW have been promoted or are in course of promotion and survey. The stations completed during the year were Luichart and Torr Achilty in the Conon Valley group and Loch Dubh, near Ullapool.† Work continued on the large hydro-electric schemes at Shira, Errochty, Glascarnoch, Glen Garry, Glen Moriston, Lawers and Breadalbane, as well as on smaller schemes at Allt-na-Lairige (Glen Fyne), Kilmelfort, near Oban, Cowal and Lussa. Construction of the dam which will raise Loch Fannich by 20 ft. and give additional long-term storage for the power stations at Grudie Bridge, Luichart and Torr Achilty was also begun.

TUNNEL DRIVING

Dealing with the constructional work, the report notes that over 13 miles of rock tunnel were driven during the year. In driving the 9-ft. Vaich tunnel and the 10-ft. Glascarnoch tunnel an average rate of 476 ft. per month was maintained by A. M. Carmichael, Limited, in spite of the fact that long hauls were necessary to get rid of the spoil. The Cementation Company also drove one of the 6½-ft. Lawers tunnels from one face at the rate of 692 ft. per month, while the Mitchell Construction Company drove 428 ft. in one week at one heading of a 10-ft. tunnel in the Breadalbane scheme. This has been hailed as a European tunnelling record. The chief reasons for these good results were the use of such equipment as mechanical shovels, which loaded the spoil into motor lorries, and pneumatic concrete placers. Progress was speeded up in the Invergarry tunnel where the concrete on the invert was placed on the top of hard-packed spoil with a cross-tie to bedrock every 50 ft. Time and labour occupied in blearing out the spoil were thus saved.

During the year, the cement plant at Trief came into full operation. This makes use of blast-furnace slag to replace 70 per cent. of the cement. The resulting concrete has given more consistent results than was anticipated and has assisted in relieving a shortage of this material. Experiments with fly ash to save 30 per cent. of the cement were also made. A pre-stressed concrete dam is being erected at Allt-na-Larrige and another, in which "pre-packed" concrete is being used, at Loch Dubh.

The installed capacity of the steam plant was 120,875 kW, the output of which was 328 million kilowatt-hours. The output of the Diesel stations remained at 55 million kilowatt-hours and all but nine of them were relegated to stand-by or reduced duty as the result of hydro-electric development and inter-connection. An experimental peat-fired station, which will be equipped with a 2,000-kW gas turbine, was under construction at Altnabreac in Caithness. Work continued on a second gas turbine in Dundee and on the 100-kW windmill at Costa Head in Orkney. During the year, 1,130 miles of 132-kV line were in commission. This included the 25-mile line over the Corrieyairack Pass

* *North of Scotland Hydro-Electric Board. Report and Accounts. January 1 to December 31, 1954.* H.M. Stationery Office, Edinburgh. [2*s.* 6*d.*]

† ENGINEERING, vol. 178, pages 495 and 629 (1954).

A CATALYST FOR INVENTIONS

ROLE OF THE NATIONAL RESEARCH DEVELOPMENT CORPORATION

Two main observations arise from the report for 1953-54 of the National Research Development Corporation: firstly, that few private inventors with something valuable to offer are in need of public assistance; and secondly, that a single invention can still have a marked effect on the structure of industry. The report, which includes a statement of accounts for the year July 1, 1953, to June 30, 1954, summarises the Corporation's aims, prospects and plans for the future and reviews its activities during the past five years. In addition, it lists with comments the projects so far undertaken, describing some of the difficulties encountered. Mention is also made of the N.R.D.C. Bulletin, an illustrated review containing particulars of inventions in quarterly abstract form, which is published and may be obtained from the Corporation's offices at 1, Tilney-street, London, W.1.

Among the new projects undertaken by the N.R.D.C. during the year considered in the report is a stereoscopic cine-camera, which would have applications not only to the motion-picture industry but also for educational, medical, scientific and technological purposes. In addition, work has been carried out on a technique for producing electrical wiring circuits by printing. By this process such circuits as those employed in radio receivers can be reproduced in quantity easily and economically, and one method of achieving this by etching copper foil was described in ENGINEERING (vol. 178, page 736, 1954).

Projects which have reached the production stage include the development of electronic digital computers, one version of which, the Ferranti "Pegasus," was described in the issue of February 18 (page 218). The Packman potato harvester (ENGINEERING, vol. 178, page 248, 1954), an aural microscope and chick-sexer, and a photogrammetric plotting instrument are other inventions already in production. Work is also proceeding on the Ricardo light steam engine (ENGINEERING, vol 178, page 442, 1954), a regenerative mechanical transmission system, a hydrocarbon synthesis project, an ion-exchange process for a natural product extraction, Burns' analgesic inhaler, pesticidal coating compositions, Sir Thomas Merton's diffraction gratings (ENGINEERING, vol. 177, pages 263 and 766, 1954), and a liquefied-gases plant. In addition, the process of extracting hecogenin from sisal juice, purifying it and forming hecogenin acetate has made good progress during the year, and the product has now been made available in large quantities as a starting point for the synthesis of cortisone and its derivatives.

The development of the hecogenin process illustrates the way in which a single discovery can effect drastic changes in the organisational structure of industry, and shows too the part played by the N.R.D.C. in bringing to the attention of one branch of enterprise discoveries made in another. In homogeneous industries such as those based on the manufacture of iron and steel, ideas spread rapidly, but in many others no medium for the interchange of information exists. In circumstances of this kind the Corporation can serve as a line of communication.

CROSS-FERTILISATION

It acted in this capacity in the case of the hitherto unrelated pharmaceutical industry of the temperate zones and the sisal plantations of the tropics. The Medical Research Council had discovered that waste sisal juice was a comparatively rich source of the rare chemical hecogenin which offered a basis for the synthesis of certain steroid hormones including cortisone. The owners of sisal plantations had no means of ascertaining the demand for this product and neither party could determine a price at which it might be economically purchased. This state of affairs might have persisted for a long time had the N.R.D.C. not entered the field.

It commissioned a pilot plant in Kenya, underwrote a full-scale production plant to be erected on the land of a sisal plantation in Tanganyika, contracted for its output and placed a development contract for the refining process, before any clear expression of requirements had been received from companies in the pharmaceutical industry. Thus within 2½ years of the original discovery a firm in the United Kingdom has been able to begin small-scale production of cortisone from hecogenin produced in East Africa and the West Indies.

The Corporation can also serve as a means of liaison between centres of learning and research, and both industry and agriculture; a more rapid inter-action of ideas may thus be promoted and science be applied to practical purposes at an accelerated rate. Another method by which the N.R.D.C. contributes to industrial progress lies in its function of administering and exploiting publicly owned patents. Thousands of British and Foreign patents and patent applications are now in the care of the Corporation, which has evolved means of dealing with them on commercial lines. These patent rights are already earning revenues which should rise steadily in the future. A third object of the Corporation is the development of private inventions where this is in the public interest. Although one or two good inventions are supported in this way each year, far fewer private inventions justifying public assistance have appeared than was anticipated.

PRIVATE INVENTORS

Perhaps many private inventors are not aware of the help they can receive from the N.R.D.C. It is clear from the success of the B.B.C. Television feature "Inventors' Club" that numerous private inventors do in fact exist, but in the case of many, large-scale financial support is probably not required. In general, to offer the community anything of great value in the highly technical world of to-day, the inventor must be in possession of a wide technological experience; most inventors of this kind are necessarily members of engineering companies, and consequently the resources required to exploit their ideas are in most cases immediately to hand.

Nevertheless, the N.R.D.C. has an important part to play. It is unlikely that any private invention can change the structure of industry to the extent that it was changed by the steam engine, but new ideas, if exploited properly, can bring independent industries into closer association, and add considerably to the national wealth. War is a notorious catalyst for the development of inventions but is hardly justified by this consideration, and industrial progress can surely be hastened by other means. One approach is that which has been adopted by the National Research Development Corporation, and it is to be hoped that in its catalytic role it will continue to be successful.

Letters to the Editor

MECHANICAL INSTABILITY

Nineteenth Century Analysis

SIR, In the review of *L'Instabilité en Mécanique* which appeared in your issue of February 11 it is stated: "Professor Rocard, however, discovered that certain forces, in quadrature with the displacement and not derivable from a potential, are capable of re-injecting energy into the system and so inducing instability." I should like to point out that Professor Rocard was far from being the first person to discover this important fact. The analysis of systems, whose differential equations are linear with constant coefficients, as given by E. J. Routh in his celebrated *Advanced Rigid Dynamics*, completely covers the case where the forces are not derivable from a potential so that the array of the stiffness coefficients is unsymmetric. This book was first published about 1860. So far as wing flutter is concerned, the importance of the unsymmetric stiffnesses was explained in the Aeronautical Research Committee monograph, *Flutter of Aeroplane Wings*, by R. A. Frazer and W. J. Duncan; this was published by H.M. Stationery Office in 1928, as R. and M. 1155. The part which those aerodynamic forces not possessing a "potential" play in feeding energy into the system when the component motions are out of phase was stressed in this monograph, while round about 1930 the "flutter engine" was devised to demonstrate the principle.

Yours faithfully,

W. J. DUNCAN.

James Watt Engineering Laboratories,
The University,
Glasgow, W.2.
February 19, 1955.

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LOW-FRICTION FLUID SEALS

Plea for Information

SIR, I read the above article in your issue of February 4 with some interest and noticed that friction was referred to in the title and in the text. The value of the article to designers and plant engineers would have been greatly enhanced if the author had quoted some values for the friction. Even the approximate order of the friction would be greatly appreciated.

Generally speaking, I have in the past found the greatest difficulty in obtaining any information regarding the friction of seals for reciprocating applications. The fundamentals involved are without doubt complex but a number of elementary measurements of the friction could be made at no great expense, which would enable the manufacturer to give some general guidance.

It would appear that by plotting the friction of seals of various sizes against pressure, the results could be correlated to eliminate the size factor. Further tests with one or two sizes would demonstrate the effect of viscosity and surface finish. The manufacturer would then have figures to quote which no reasonable designer would expect to be exact but rather indicative of the order.

Yours faithfully,

B. COOKE.

Research Department,
Vickers-Armstrongs Ltd.,
Elswick Works,
Newcastle-upon-Tyne, 4.
February 18, 1955.

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THICK-WALLED CYLINDERS UNDER INTERNAL PRESSURE

Dr. van Iterson's Formula

SIR, Referring to the article on the ultimate strength of thick-walled cylinders which appeared in ENGINEERING on pages 80 and 114 (January 21 and 28) the exact formula to calculate the wall-thickness of tubes is:

$$p = R \log_e \frac{b}{a},$$

where p = the internal pressure, R = the ultimate tensile stress determined from the tension test, and b and a = the external nd internal diameters of the tube.

I think that, although it is simple, it is better not to give the proof of this formula here, because this was done in ENGINEERING, vol. 93, page 22 (1912), and in my book *Plasticity in Engineering* (page 10).

The approximate formula for thin-walled tubes is:

$$p = \frac{R}{2} \frac{b-a}{a}.$$

For thin-walled tubes you will find the same wall by applying both formulae, but not so when K, the proportion of external to internal diameter, is large. The exact formula must then be used. When using thick-walled tubes for steam-pipes at high pressures and high temperatures, the exact formula for calculating the wall-thickness is of great importance. The exact formula gives a small difference with the tests made by Dr. Crossland and Mr. Bones at values of K greater than are used in practice for steam pipes, but the experiments are so exact that I will give the explanation here. The difference is due to the fact that the exact formula takes no notice of the increase in diameter as the margin of safety does not allow a bursting pressure.

In the Table, I give the 13 ultimate tensile strengths calculated with the exact formula. I have re-arranged the table on page 144 in order of increasing ratio of the diameters, $K = \frac{b}{a}$. The figures in the last column should slowly decrease. I have shown the ultimate strength of the doubtful cylinders 1, 3, 4 and 6, in italics.

Cylinder No.	K	Ultimate pressure, tons per sq. in.	Mean ultimate tensile strength, tons per sq. in.
2	1·331	9·32	32·2
1	1·572	15·5	*34·4*
6	1·775	19·2	*33*
8	1·876	20·1	32
3	1·998	22·3	*32·2*
11	2·130	23·6	31·6
4	2·29	27	*32·6*
9	2·482	28·7	32·7
5	2·66	30·25	31
7	2·904	32·65	30·6
10	3·176	35	30·3
12	3·602	38	29·6
13	3·717	39·5	30

That there is not accordance between these ultimate tensile stresses and the tensile tests, which were 32, 32·2, 32·9, 33·2 and 34·1 tons per square inch, is because the tensile stresses are based on the original area of the specimen. The above results are calculated from the thick-cylinder tests in which the reduction of area at failure is not necessarily similar.

Yours faithfully,

F. VAN ITERSON.

The Hague,
Waalsdorperweg 108,
February 11, 1955.

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ARTIST OF ENGINEERING

Lithographs of Joseph Pennell

SIR, Please permit me to express my appreciation of your kind review of my book *A History of the School of Engineering, Columbia University* (page 105, issue of January 28).

As an amateur artist I was much interested in the leading article in the same issue, "Patron of the Arts." I was surprised, however, to note that you did not mention the late Joseph Pennell. I had just been looking over the beautiful fully-illustrated catalogue of his truly remarkable lithographs. You will undoubtedly recall those of the Panama Canal and the numerous steel-works, factories, etc., and his drawings of British and U.S. war industries. All of this—and it must come to at least half of his artistic output in this field (i.e., lithographs)—he referred to as "The Wonder of Work." In this wonder he found a never-failing source of inspiration for the exercise of his artistic abilities.

He was, in short, *the* artist of engineering and industry, and while others have done great bridges Pennell saw the spirit of man battling with Nature's forces in blast furnaces and shops, in shipyards and foundries. Our profession owes a great debt to this Anglo-American artist —the first notable artist to interpret "The Wonder of Work."

Faithfully yours,

JAMES K. FINCH.

88 Morningside-drive,
New York 27,
U.S.A.
February 15, 1955.

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CONSULTING ENGINEERS AND THE RAILWAY PLAN

Sir Brian Robertson's Policy

Speaking at the annual dinner of the Association of Consulting Engineers on February 21, Sir Brian Robertson, chairman of the British Transport Commission, said that in their plan for the modernisation of British Railways the Commission had set their sights very high. In several important respects they had deliberately demanded more than was proposed as the limit of sure accomplishment by their technical advisers.

Their own engineering staff were inadequate in numbers to carry out the plan. Quite a lot of young engineers had joined the railways for a while for their early training, but they had then left for more lucrative fields. That serious situation must be remedied, and very special efforts were being made to that end. In any case the established engineering staff of British Railways could not be expected to be adequate to cope with the extraordinary demands which such an immense plan would impose upon it. Therefore, with an engineering staff far, far short of establishment, British Railways would be doubly dependent on outside assistance, and they were looking to consulting engineers to provide it. Sir Brian said that the Commission should perhaps set consulting engineers some problems which were rather abnormal and arose from the very magnitude of the task. He hoped that discussions now going on between railway officers and representatives of the profession would discover the most fruitful and effective means of collaboration.

Mr. T. G. N. Haldane, chairman of the Association, said that by helping to raise the standard of living in undeveloped countries, consulting engineers were helping to promote political stability. The same theme was taken up by the Rt. Hon. A. R. W. Low (Minister of State, Board of Trade), who replied to the toast of "The Guests" proposed by Mr. V. A. M. Robertson. Mr. Low appealed to consulting engineers to take temporary appointments with the various bodies which are helping undeveloped countries. It had been said that exports followed the flag, but to-day exports followed the experts. There was £200 million worth of work abroad, now in hand, for which British consulting engineers were responsible.

(*Editorial comment on page* 257.)

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HEAT PUMP TO BE REPLACED

According to a recommendation placed before the London County Council, the heat pump installed at the Royal Festival Hall is to be replaced by a permanent cooling plant at an estimated cost of £28,700. No really satisfactory comparison figures were obtained with the experimental plant as the pump proved too large for the heat capacity required.

CONTRACTS

Continuous Strip Galvanising Equipment. In connection with the order placed by Richard Thomas and Baldwins Ltd., for the supply of continuous steel-strip galvanising equipment at their Ebbw Vale Works, some particulars of which were given on page 165 of our issue of February 11, we learn from the contractors, HEAD WRIGHTSON MACHINE CO., LTD., Middlesbrough, that they have now placed orders for the furnace and electrical equipment. BIRLEC LTD. will supply the special processing furnace which will be divided into four sections employing open-flame, radiant-tube and electric heating and will have an overall length of 180 ft. From the entry to the exit end of the line, the continuous strip travels a distance of 1,600 ft., and the electrical equipment, to be supplied by the ENGLISH ELECTRIC CO. LTD., is designed to give the very close control of line speed and tension which is essential when dealing with this length of light-gauge strip. A total of 75 electric motors are included in the equipment.

Television Equipment. The latest of a series of contracts signed between the British Broadcasting Co. Ltd., Chelmsford, Essex, for equipment for Corporation and MARCONI'S WIRELESS TELEGRAPH the Crystal Palace television station, provides for the construction and erection of the transmitting aerial array. In the system planned for this station, the two 15-kW vision transmitters and the two 4½-kW sound transmitters will be fed into one aerial. This will be accomplished by feeding the respective outputs from one vision and one sound transmitter into a combining unit, whence it is conducted by a common main transmission line to half the aerial system. The remaining pair of transmitters will be connected in a similar manner to the other half of the aerial.

Railway Wagons. The British Transport Commission have placed a contract for 111 fifty-ton rail, sleeper and ballast wagons with HEAD, WRIGHTSON & CO. LTD., Teesdale Iron Works, Thornaby-on-Tees.

Steelworks Mechanical Plant. An order valued at nearly £500,000 for the complete mechanical plant for the Irlam development scheme of the Lancashire Steel Corporation Ltd., has been received by RICHARD SUTCLIFFE LTD., Horbury, Wakefield. It includes the supply of fifteen 36-in. wide belt conveyors, five plate feeders and ancillary belt trippers, crushers and junction houses, a wagon tippler, grizzly screens and cone crushers, for the conveyance and treatment of iron ore, coal and coke.

Electric Cable. The Electricity Commission of New South Wales, Australia, have placed a substantial order with BRITISH INSULATED CALLENDER'S CABLES LTD. It is for the supply of 30,000 yards of high-voltage cable to form a double-circuit 8½-mile link between Bunnerong power station and Canterbury substation, Sydney. It is expected that the cable will be in operation early next year. The cable chosen is a three-core 132-kV impregnated pressure cable which will be manufactured in England although its installation and maintenance will be carried out by the firm's affiliated Australian company, British Insulated Callender's Cables (Australia) Pty., Ltd.

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INTERNATIONAL COMMISSION ON LARGE DAMS

Paris Conference in May

The French Committee on Large Dams, in conjunction with the Algerian, Moroccan and Tunisian committees, as joint hosts for the fifth congress of the International Commission on Large Dams of the World Power Conference, have recently issued the second bulletin in respect of the forthcoming meeting in Paris. The time-table for the congress has now been re-arranged from that published previously. The study tours in France will now take place before the opening of the congress proper, from May 23 until May 28, 1955. The congress, as previously announced, will be held in Paris from May 31 until June 4, and will be followed by the study tours in North Africa from June 5 until June 12.

Copies of the bulletin, containing application forms in respect of the congress, the study tours, accommodation and transport, may be obtained from the secretary, British National Committee on Large Dams, 201-2 Grand Buildings, Trafalgar-square, London, W.C.2.

THE IRON AND STEEL INDUSTRY

A FIVE-YEAR DEVELOPMENT PLAN

The production of steel is growing rapidly and, it is anticipated, should reach 19½ million ingot tons during the present year; the output in 1954 was 18,520,000 tons and in 1953 17,608,000 tons. It is estimated that the expected demand three years hence, namely, in 1958, will be 22½ million tons. It is stressed in a report* prepared by the Iron and Steel Board under Section 16 (2) of the Iron and Steel Act, 1953, and laid before Parliament on February 22, that the total for 1958 is based on the assumption that home investment, which is the largest element in steel requirement, will increase by 5 per cent. per annum during the period 1953 to 1958. It is also assumed that the export of metal goods will expand similarly, that the demand for motor cars and other durable consumer goods may increase rather more rapidly, and that defence requirements will not change significantly from the level of 1953.

STEELMAKING PLANTS

Attention is drawn to the fact that in so far as the production of steel ingots is concerned, the steady growth in the size of open-hearth furnaces during the past 20-odd years, quite apart from other technical improvements, has resulted in a continually rising output of steel per furnace installed. Since the number of men needed to work a large furnace is not substantially different from the number necessary for a small one, this, in itself, represents an appreciable increase in productivity. Moreover, the possibilities of further improvement are by no means exhausted.

Extensions to steel melting shops are under way at the Shotton Works of John Summers and Sons, Limited, the West Hartlepool and Cargo Fleet Works of the South Durham Steel and Iron Company, Limited, the Bilston Works of Stewarts and Lloyds, Limited, and the Staffordshire plant of the Round Oak Steelworks, Limited. New melting shops are in course of completion, or have been put into service, at the Stocksbridge Works of Samuel Fox and Company, Limited, and the works of the Lancashire Steel Corporation, Limited, and Colvilles Limited.

STEEL SHEET AND TIN-PLATE

As regards steel-finishing capacity, special attention is being paid to wide flat products. Over the five-year period, the finishing capacity for tin-plate will increase from 775,000 tons in 1953 and 875,000 tons in 1954 to a potential output of 1,450,000 tons in 1958. Similarly, the potential output of steel sheet in 1958 is placed at 2,650,000 tons against actual deliveries, in 1953, of 1,786,000 tons and estimated deliveries in 1954 of 2,029,000 tons. Material contributions to the output of sheet steel are to be made as a result of development schemes already in hand at the Ebbw Vale Works of Richard Thomas and Baldwins Limited, the Margam Works of the Steel Company of Wales, Limited, and the Shotton Works of John Summers and Sons, Limited.

At the Ebbw Vale Works additional equipment to permit the manufacture of lighter-gauge sheet is due to be completed towards the end of the present year. On completion, the output of hot-rolled coil will be increased from 700,000 tons to 800,000 tons a year. The completion of the scheme of the Steel Company of Wales at Margam is due in 1956, as a result of which the production of sheet is expected to rise from 460,000 tons to 650,000 tons a year. Extensions at the Shotton Works are due to be completed by the middle of 1956 when it it is estimated that the firm's output of prime sheets and plates will be increased to 850,000 tons a year.

In addition, some indirect contribution will be made, by 1958, from a medium strip mill which is being installed at the Steel, Peech and Tozer Works in Sheffield and is designed eventually to produce 250,000 tons a year. This will meet, in part, a requirement now satisfied by slitting sheet produced in wide-strip mills.

In 1953, home consumers of tin-plate were taking 515,000 tons a year of this commodity, compared with 375,000 tons before the late war. A further growth in the demand for tin-plate at home is forecast, and fresh uses for containers made of tin-plate are expected to develop when adequate supplies are available. Exports, it is considered, might be expanded considerably, especially to Commonwealth markets. An estimate of the demand in 1958, prepared in collaboration with the principal users and makers of tin-plate, shows a prospective requirement of 1·36 million tons. The estimate for home demand represents an increase of nearly 100 per cent. over the average deliveries to the home market in 1936-39. It is anticipated that by 1958 the capacity of tin-plate producing plants should be in excess of these requirements.

Some emphasis is laid, in the report, on the fact that the future of sheet and tin-plate production undoubtedly lies with the modern strip mills on account of their ability to produce a better-quality article and at the same time to obtain the benefits of large-scale production. The feasibility of further expansion at the existing strip mills, and also the possible need for additional facilities, are under examination.

PIG IRON, COKE AND IRON ORE

The output of pig iron, it is stated in the report, should increase from 11·175 million tons in 1953 to 15·150 million tons in 1958. Blast furnaces with large-hearth diameters are being built in Lancashire, on the North-East Coast, in Scotland, and in Wales. It is estimated that the output of pig iron, with the normal increase in home-scrap supplies, should meet the requirements of the steelworks in 1958, apart from a small balance which is expected to be available either from imports or from some further expansion in home outputs of these materials.

In 1953 the iron and steel industry manufactured for its own use in blast-furnaces some 8·5 million tons of coke. The industry also purchased in that year 3·7 million tons of coke from the National Coal Board and other suppliers. Future plans assume a continuance of these purchases at about the same level. The additional supplies of coke needed to increase the output of pig iron, in accordance with the general policy of the iron and steel industry, will be provided by the expansion of coke ovens at iron and steel works. To balance the production of 15·15 million tons of pig iron, quoted as the prospective output for 1958, would require the increase of coke supplies by about 3 million tons. So far, coke-oven capacity has been firmly planned to provide this tonnage.

As regards iron-ore supplies, it is contemplated that, for a production of 15·15 million tons of pig iron, the output of home ore should be raised from 15·87 million tons in 1954 to 17·6 million tons in 1958. Imports, including manganese ore, would amount, in 1958, to 15·7 million tons for blast furnaces and sintering plants, and about 1·25 million tons for oxidising purposes in steel furnaces. Actual imports of ore, including manganese ore, totalled 11·26 million tons in 1954.

CAPITAL COSTS

The total cost of the schemes included in the programme, for the period 1953 to 1958 is estimated at just over £250 million. Major schemes of modernisation or expansion are at present in progress at 25 different steelworks. With further schemes which are likely to be approved in the next few years, but which, in the main, will affect production after 1958, expenditure over the five years to 1958 is likely to total something over £300 million.

* "Development of the Iron and Steel Industry, 1953 to 1958," H.M. Stationery Office. [1*s.* 9*d.*, net.]

PERSONAL

SIR JOHN GREEN has relinquished his position as a member of the Iron and Steel Holding and Realisation Agency but has agreed to be available to the Agency in an advisory capacity. He has rejoined the board of Thos. Firth and John Brown Ltd., Sheffield, and has been appointed chairman. DR. C. SYKES, F.R.S., has been made deputy chairman in addition to his office as managing director.

SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng., director of research and education, Associated Electrical Industries Ltd., has retired from executive duties, but is retained in a consultative capacity. MR. E. P. GRIMSDICK, assistant to the managing director, Associated Electrical Industries, has also retired from executive duties. He is retained in a consultative capacity on matters concerning India and Pakistan.

In connection with the retirement, a year hence, of SIR JOHN S. BOYD from the position of permanent vice-president of the Shipbuilding Employers' Federation, 1 Chester-street, Grosvenor-place, London, S.W.1, the Federation have appointed MR. NORMAN A. SLOAN, B.L., Q.C., as director designate, as from March 1, with a view to his succeeding Sir John on his retirement.

GENERAL SIR KENNETH N. CRAWFORD, K.C.B., M.C., has been elected to the board of directors of Cyanamid Products Ltd., the London subsidiary company of the American Cyanamid Co. of New York.

DR. J. H. WATSON, M.B.E., M.C., B.Sc., A.R.S.M., has been appointed chemist and assayer of the Royal Mint, London, E.C.3, in succession to MR. W. A. C. NEWMAN, C.B.E., B.Sc., A.R.S.M., F.R.I.C., who has retired.

CAPTAIN A. R. MANGNALL, M.C., chairman and managing director of the Hydraulic Engineering Co. Ltd., Chester and London, has joined the boards of the General Hydraulic Power Co. Ltd., the Hatfield Insurance Co. Ltd., Hypower Ltd., the Liverpool Hydraulic Power Co., and the London Hydraulic Power Co.

DR. W. H. J. VERNON, O.B.E., who recently retired from his post as head of the corrosion section of the Chemical Research Laboratory of the Department of Scientific and Industrial Research, is to receive the Whitney Award for 1955 of the National Association of Corrosion Engineers of the United States. The award has only once previously come to this country, when DR. U. R. EVANS, F.R.S., was the recipient in 1948.

MR. J. A. WYKES has retired from the board of Hoover Ltd., Perivale, Greenford, Middlesex, on account of ill health. MR. S. ROBERTS, the deputy managing director of the company, has been appointed managing director in his place.

MR. A. E. COOK, who retired from the managing directorship of Cravens Ltd., wagon and carriage builders, Sheffield, in 1951, has now relinquished his seat on the board of the company, after 44 years of service with the firm.

MR. G. T. W. WHITEHEAD, O.B.E., M.I.Mech.E., previously assistant general manager (works), has been appointed general manager (works) to Johnson and Phillips Ltd., Charlton, London, S.E.7.

MR. S. F. H. PARSONS, formerly director and chief engineer, C.A.V. Ltd., Acton, London, W.3, is now acting as a special-duty director in a consultative capacity. MR. K. BROOK, A.M.I.Mech.E., formerly chief experimental engineer, has been appointed to the board as an executive director.

MR. C. WILSON, who joined the staff of the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1, on October 1, 1953, as assistant to the general manager, has been appointed deputy general manager.

The directors of Head, Wrightson & Co. Ltd., Teesdale Iron Works, Thornaby-on-Tees, announce that, as from February 1, MR. R. B. W. BOLLAND has been appointed a director of Head Wrightson Aluminium Ltd. He still retains his position as general manager of the subsidiary company.

MR. C. J. CARTER, who has been assistant director, navigation, in the Directorate of Instrument Research and Development, Ministry of Supply, since 1951, has been promoted to the position of deputy chief scientific officer and has been appointed director of Instrument Research and Development.

MR. E. H. C. LEATHER, M.P., has been retained by Leyland Motors Ltd., Leyland, Lancashire, in a consultative capacity on economic affairs, particularly in connection with their export activities.

MR. DOUGLAS RAMSDEN has been appointed director and secretary of Villiers Australia Pty. Ltd., Ballarat, subsidiary company of the Villiers Engineering Co. Ltd., manufacturers of small-capacity air-cooled petrol engines, Wolverhampton.

COMMERCIAL

Arrangements for the purchase, by the DAVID BROWN CORPORATION LTD., Huddersfield, of a controlling interest in HARRISON, MCGREGOR AND GUEST, LTD., agricultural engineers, Leigh, Lancashire, have now been completed. Accordingly, the board of directors of Harrison, McGregor and Guest has been reconstituted with MR. DAVID BROWN, MR. J. C. R. BIRNEY, MR. WALTER DREW, and MR. J. WHITEHEAD as members.

THE IRON AND STEEL HOLDING AND REALISATION AGENCY announce that the sale to N. HINGLEY AND SON, LTD., of the Agency's holding of the entire share capital in JOHN BAGNALL & SONS LTD., has been completed for the sum of £200,000. Thus, this company again becomes a wholly-owned subsidiary company of N. Hingley & Sons Ltd.

A company known as GEOTHERMAL DEVELOPMENT LTD., in which the New Zealand Government and the United Kingdom Atomic Energy Authority are the sole shareholders, has now been incorporated. It is a joint enterprise to undertake the construction of a factory and the subsequent production of heavy water and electric power from Geo-thermal steam in the Wairakei district of North Island, New Zealand. The directors are MR. B. C. ASHWIN, chairman (N.Z.), MR. A. E. DAVENPORT (N.Z.), SIR DONALD PERROTT (U.K.), MR. C. W. C. TURNER (N.Z.), and MR. A. S. WHITE (U.K.).

HUMPHREYS AND GLASGOW LTD., Humglas House, Carlisle-place, London, S.W.1, have established a branch office at 82, Elizabeth-street, Sydney, New South Wales, Australia. It will be under the control of MR. A. S. HUMPHRYS and MR. J. R. SPANGARO and, it is anticipated, will be in operation early in May.

An arrangement has been concluded between GOODENOUGH PUMPS LTD., 70-72 London-road, Twickenham, Middlesex, and GODFREY ENGINEERING CO., LTD., Montreal, Canada, for the manufacture of the complete range of Goodenough pumps in Canada, and the marketing of this range throughout Canada and the United States. The pumps will be sold under the trade mark Godfrey-Goodenough.

JENOLITE LTD. are to move their offices from Piazza Chambers, Covent Garden, London, W.C.2, to new premises at 13-17 Rathbone-street, London, W.1, on March 14. (Telephone: MUSeum 5411.)

THE BRITISH WEDGE WIRE CO. LTD., Academy-street, Warrington, have moved their London offices and those of MODERN MECHANISATION LTD. from 687 Finchley-road, N.W.2, to Elmswood House, Bounds Green-road, N.11. (Telephone: BOWes Park 8442.)

VOLTARC TUBES INC. have been granted an exclusive licence for the United States, for an electrode which prevents end-dulling of cold cathode fluorescent tubes when the temperature falls, produced by CLAUDE-GENERAL NEON LIGHTS LTD., in this country.

THE EXPORT CREDITS GUARANTEE DEPARTMENT have opened a new branch in Newcastle-upon-Tyne, to serve the areas of Tyneside, Wearside and Teesside. Pending the completion of the new offices, the manager of the branch, MR. J. A. BOOKLESS, will operate from temporary premises at 93A Grey-street, Newcastle-upon-Tyne, 1. (Telephone: Newcastle 26011.)

BIRLEC LTD., Tyburn-road, Erdington, Birmingham 24, have moved their London area office to Ediswan House, 155-161 Charing Cross-road, London, W.C.1. (Telephone: GERrard 8660) and their Newcastle-upon-Tyne office to c/o The British Thomson-Houston Co. Ltd., 9 Higham-place, Newcastle-upon-Tyne, 1. (Telephone: Newcastle 25040.)

THE PULSOMETER ENGINEERING CO. LTD., Nine Elms Iron Works, Reading, have appointed S.W. CARTY & SON, 12 Lower Mount-street, Dublin, as their agents for Eire.

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Obituary

SIR STEPHEN J. PIGOTT

An American Engineer on Clydebank

For an engineer to become managing director of a major British shipyard is somewhat unusual but for an American engineer to do so is certainly exceptional. This, however, was one of the several distinctions enjoyed by Sir Stephen J. Pigott, formerly managing director of the Clydebank shipyard and marine engine works of John Brown and Company, Limited, whose death, we regret to record, occurred on February 27 at his home in Dumfriesshire. He was 75

years of age, and had spent 41 of those years in the service of John Brown and Company at the time of his retirement in 1949.

Stephen Joseph Pigott was born on January 30, 1880, in the town of Cornwall, in New York State, where he received his schooling. At the age of 16, he entered the works of the Street Railroad Company, of Hartford, Connecticut, to serve an engineering apprenticeship, but left them after a short time for the shops of the New York, New Haven and Hartford Rail Road, with whom he remained until 1899. He then went to Columbia University, where he obtained a degree in mechanical engineering in 1903. For the next five years he was with the International Curtis Marine Turbine Company, founded by Charles Gordon Curtis—who died not quite two years ago, at the age of 93—to promote the application to ship propulsion of the velocity-compounded steam turbine bearing his name. For the latter part of this period, Pigott was in charge of the design of Curtis marine turbines; hence it came about that, when John Brown and Company took out a licence in 1908 to construct Curtis turbines, he was engaged by them to undertake the supervision of the design work—it is understood, at the instigation of the British Admiralty, who had been watching with interest the performance of the scout Salem of the United States Navy and the Japanese heavy cruiser Ibuki, in both of which Curtis turbines had been fitted.

He was then only 28 years of age, but he proved himself fully equal to the responsibility. Twelve years later, he was made a local director, and in another 14 years a director of the main company. It was in the following year, 1935, that he was appointed as director in charge of the Clydebank works, following the retirement of Sir Thomas Bell, a position which he held until his own retirement in 1949. Of the many notable vessels completed at Clydebank during his regime, it is sufficient to mention only the battleship Hood and the Cunard liners Queen Mary and Queen Elizabeth.

Sir Stephen, who received his knighthood in 1939, had served for more than 20 years on the Council of the Institution of Naval Architects, of which he was made a Vice-President in 1941. He was also a Member of the Institution of Civil Engineers and of the Institution of Engineers and Shipbuilders in Scotland, and a former President of the Institute of Marine Engineers, to which he delivered, in 1937, a memorable address on "Three Score Years of Development in Marine Engineering." In 1940 he gave the Parsons Memorial Lecture to the North-East Coast Institution of Engineers and Shipbuilders on "The Engining of Highly Powered Ships"; in various respects it might be regarded as a supplement to the paper which he read before the Institution of Naval Architects in 1937 on "Some Special Features of the S.S. Queen

Mary." He served for a number of years on the Committee of Lloyd's Register of Shipping, and was a Liveryman of the Worshipful Company of Shipwrights. In 1936, the honorary degree of Doctor of Science was conferred upon him by Columbia University, from which he had graduated 33 years before; and in 1938, the American Society of Mechanical Engineers awarded him the Society's Medal "for outstanding leadership in marine propulsion and construction." His physical stature was comparable with his professional, and his imposing presence and genial company will be greatly missed, especially at the Spring Meetings of the Institution of Naval Architects.

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MR. NORMAN HADDON

Railway Rolling-Stock Engineer

We note also with regret the sudden death of Mr. Norman Haddon which occurred on February 23. Mr. Haddon, who succeeded Mr. A. T. Cheesley as director and production general manager of the Metropolitan-Cammell Carriage and Wagon Company, Limited, Metropolitan-road, Saltley, Birmingham, 8, as recently as January 1, 1954, was born on September 6, 1899, and received his general education at Dulwich College. He saw service with the Royal Air Force during the war of 1914-18 and, on demobilisation in 1918, became a pupil in the works of W. H. Dorman and Company, Limited, Stafford. In November, 1921, Mr. Haddon joined the staff of the Metropolitan Carriage Wagon and Finance Company, Limited, at Saltley, and after nearly three years of service in the drawing office was appointed assistant works manager in the Old Park Works of the firm, at Wednesbury, Staffordshire. In 1926, he was made works manager at Oldbury, but some seven years later left to join a firm of industrial consulting engineers.

On the outbreak of war in 1939, as a captain in the Territorial Army Reserve of Officers, Mr. Haddon was recalled for service with the Royal Artillery. In February, 1941, however, he was released from the Army and re-joined the staff of the Metropolitan-Cammell Carriage and Wagon Company, Limited, as works manager of the firm's Old Park Works at Wednesbury. In August, 1948, he was transferred to the Saltley Works as works manager and continued in this capacity until his appointment as director and production general manager as stated above. Mr. Haddon was also a director of Metropolitan-Cammell-Weymann, Limited. He was elected a member of the Institution of Locomotive Engineers in 1931.

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PROFESSOR C. O. BANNISTER

A Teacher of Metallurgical Science

It is with regret that we record the death of Professor C. O. Bannister, which occurred on February 22. Charles Olden Bannister was Professor Emeritus of Metallurgy in the University of Liverpool and was born in 1876, at Cradley Heath, Staffordshire. He was educated at Edward VI Grammar School, Stourbridge, and entered the Royal School of Mines, London, in 1896. In 1899 he was awarded the School's Bessemer Medal and Prize, and in 1901 obtained a first-class associateship of the School (A.R.S.M.) in metallurgy with honours. In 1902, Bannister won a Matthey Prize and in the following year was awarded a Carnegie Research Scholarship by the Iron and Steel Institute, this enabled him to carry out an investigation on the relation between the type of fracture and the microstructure of broken steel test-pieces.

In 1903 Bannister entered upon his career as a teacher of metallurgical science which was to extend over a period of nearly 40 years. It was in that year that he became head of the Metallurgy Department in the Sir John Cass Technical Institute, London, and remained in that position until 1919. Meanwhile, he also practised, from 1913 until 1920 as a consulting metallurgist with Messrs. Edward Riley and Harbord, of Westminster.

In 1920 Bannister was appointed Professor of Metallurgy in the University of Liverpool and continued his teaching and research work there until his retirement and appointment as Emeritus Professor in 1941. He was a Master of Engineering of Liverpool University, and an original member of the Institute of Metals. He was elected an associate member of the Institution of Mining and Metallurgy in 1906, and transferred to the class of member in 1908. He joined the Iron and Steel Institute in 1913, and was also for many years a Fellow of the Royal Institute of Chemistry.

Professor Bannister was first and foremost a teacher, but he also conducted researches over a wide field. In addition to his studies on the microstructure of fractured steel specimens, he carried out work on the case-hardening of mild steel and on the analysis and heat treatment of special and other steels. In the non-ferrous metal field he investigated various processes connected with the smelting of zinc and the corrosion of ancient metal specimens, and conducted experiments on the assay of auriferous tin-stone, the roasting of galena, and the crystallisation of gold from the liquid state. Among his last notable contributions to learned societies was a paper, written in collaboration with Dr. R. Rigby, on the "Influence of Light on the Electrode Potential and Corrosion Phenomena of Certain Non-Ferrous Metals." This was presented before the Institute of Metals in 1936.

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MR. R. D. METCALFE

Designer and Manufacturer of Injectors

Mr. Richard David Metcalfe, whose death we regret to record, took place at his home at Poynton, Cheshire, on February 20, was the chairman of the directors of Davies and Metcalfe, Limited, Injector Works, Romiley, near Stockport, Cheshire. He was born at Aberystwyth in 1876 and attended Ardwyn Grammar School, in his native town, from 1886 until 1889. At the early age of 13 he became an apprentice at the Rhudol Foundry in Aberystwyth, and three years later was a student at Lettenhall College, Wolverhampton, for a period of twelve months. In 1893 Mr. Metcalfe entered upon a four-year pupilage at the Doncaster Works of the Great Northern Railway Company, meanwhile continuing his technical education by taking evening courses at the University of Leeds. On completing his pupilage in 1897, he remained with the Great Northern Company as draughtsman in the Locomotive Department at Doncaster, for three years. His long association with the firm of Davies and Metcalfe, Limited, commenced in 1900, when he was appointed works manager at Romiley.

Mr. Metcalfe became a director of the firm in 1912. Subsequently, he was elected joint managing director, then managing director, and finally chairman, which position he was occupying at the time of his death. For many years he was engaged on the design and production of hot-water and exhaust-steam injectors, vacuum-brake and other types of ejectors, and he was the patentee or co-patentee of many improvements in these components. He was elected a member of the Institute of Metals in 1918, of the Institution of Mechanical Engineers in 1922 and of the Institution of Locomotive Engineers in 1927. He was also for many years a member of the Manchester Association of Engineers.

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We also regret to record the death of:—

MR. BERTRAM HENRY SHEFFIELD JENNINGS, at his home at Haywards Heath, Sussex, on February 10, at the age of 52. He was made export manager of Standard Telephones and Cables Ltd. in 1938, having joined the firm, then Western Electric Co., at North Woolwich in 1919.

MR. WILLIAM EDWARD EVANS, A.M.I.E.E., at the General Hospital, Birmingham, on February 9, at the age of 67. Mr. Evans, who served his apprenticeship with Vickers Ltd., Sheffield, joined the Witton Works, Birmingham, of the General Electric Co. Ltd., in 1910, and had occupied the position of manager of the contract department continuously for the past 44 years.

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SOUTH AFRICAN GOLD MINES

The South African gold mines have provided such an enormous market for the British engineering industry for so many years that the continuance of this market is of great importance. Much of the demand has been for the "developing mines," and most of the Orange Free State mines, on which there has been considerable capital expenditure since the war, are now at or approaching the production stage. In consequence, a falling off in orders for plant might be expected. It takes at least £10 million to bring an average mine into production and a substantial part of this goes in machinery and equipment.

The development of the Free State has given rise to many difficulties. It has been carried out in a period of rapid inflation so that nearly all capital costs have greatly exceeded the original estimates. For this reason some of the mines, such as Welkom, have been brought into production much earlier than would otherwise have been the case and this partially accounts for the fact that results have been disappointing. Another reason, which applies especially to Freddies, the most disappointing of all the Orange Free State mines, has been the very extensive faulting. The purely mining problems encountered, notably the khaki shale and the water (which has led to very large orders for pumps) have been more or less overcome. Western Holdings, President Brand, President Steyn and St. Helena, all adjacent and comprising the central area of the goldfield, all seem to have an assured future. Free State Geduld, to the north of them and immediately south of Freddies, are a stock market favourite, partly owing to their exceptional bore-hole and development results, though as they have not yet started mining it is rather early to attempt to assess their future. Neither the mines at the extreme north of the field (Loraine and Jeannette) nor those to the extreme south (Harmony, Virginia and Merriespruit) seem as promising as those in the centre. Nevertheless, there are prospects for at least one new mine (Saaiplaas) adjacent to Harmony, and possibly others at the extreme north of the field, so that while capital expenditure on new mines in the Orange Free State is well past the peak, it has not yet finished.

The biggest investment in the Orange Free State has been made by Anglo-American. Of the older mining finance houses, Union Corporation have only one mine in the area (St. Helena). The recent announcement that Union Corporation are to start sinking the first shaft of a new mine in the Bethal district on the Far East Rand in July is therefore of great interest. There are expected to be at least two or three new mines in the area and possibly substantially more. While the area is not another Orange Free State goldfield, it certainly looks as if it would result in a continuance of capital expenditure for some years. The Klerksdorp mines to the far west are also continuing to develop, Buffelsfontein and Hartebeestfontein being the most recent "developers" in that area, both of them showing good prospects.

Expenditure on uranium plants has, of course, been on a very large scale during the last two or three years, but this also has passed its peak, though a certain number of plant extensions are in progress, for example, at Randfontein. A good deal of the plant has been American. The recent improvement in the labour position at the mines is likely to lead to a continued high level of output with attendant demand for consumable stores, such as drills, and replacements such as motors, compressors, etc.

BOOK REVIEWS

The Steel Skeleton. Vol. I: Elastic Behaviour and Design. By J. F. BAKER. *Cambridge University Press*, 200 *Euston-road, London, N.W.*1. (42*s.*)

In any research into the literature of the theory and design of structures the reader is immediately made aware of the shortage of experimental evidence on the behaviour of actual structures as compared with the large amount of purely theoretical analysis of the subject. There are a number of reasons for this, included among which may be mentioned the comparatively recent introduction of suitable instruments for measuring strain, the time taken by an experimental investigation, and the inconvenience and cost of making the strain readings on a structure where the interest of all concerned is directed towards the completion of work on the site.

The first successful tests on actual steel-framed buildings were the early results of the work of the Steel Structures Research Committee, which was formed in 1929 to investigate the application of modern theory to the design of all forms of steel structures. Strain measurements were made on an hotel building, an office building, and a residential flats building, and were intended to guide the development of the future design of such structures. A great deal of information was collected together but among structural engineers to-day the experimental work is not as well known as it might be. The documents usually have to be consulted in a library since, owing to the destruction of stock during the war, the Reports of the Committee are no longer generally obtainable.

This first volume of Professor Baker's book *The Steel Skeleton* should be regarded as setting the stage for volume II. Its sub-title "Elastic Behaviour and Design" clearly indicates its contents, while volume II, to be called "Plastic Behaviour and Design," can be expected to give details of the more recent work of the author who was the Technical Officer of the Steel Structures Committee. The present volume is of great interest in itself, since it deals with the various stages of the work of the Committee. The review of steel-framed building regulations throughout the world, the survey for London of the live loads that buildings have to withstand, the choice of a strain gauge and the experimental investigations on the three selected structures, are all matters that form most interesting and informative reading. The choice made then of using vibrating-wire or acoustic strain gauges has been proved in more recent investigations to have been the correct one for accurate long-term strain measurements on structures.

The first experimental frame was specially erected at the Building Research Station, and the most important information obtained from that investigation was that the light cleated connections gave a type of stress distribution very similar to that which would have been obtained on the basis of the calculations for a frame with fully rigid joints. This fact was confirmed by the measurements from three practical test frames. The high sensitivity of the steel structures to the practical matters of local fit and the bolting up of connections was also made clear by the strain measurements. The behaviour of beam-to-stanchion connections was also studied to form the basis of the development of a design method which is fully dealt with in the later chapters of Professor Baker's book, and was based completely on the experimental measurements taken from actual structures. The final chapter in the volume, entitled "The Reception of the Recommendation," states very fairly the reasons for the general lack of enthusiasm for the proposals which were made for a new rational basis of design. This chapter also deals with the revision in 1948 of B.S. 449, and concludes with the expectation that a method of design based upon plastic behaviour will be developed in which the properties of a structure made of so ductile a material as mild steel are exploited to the full. Two appendices are added to this volume, the first on "Design of Rigidly Jointed Frames" and the second on the "Design of Framed Buildings against High Explosive Bombs." The latter includes two remarkable photographs showing the inherent strength of an orthodox steel frame when the stanchions at the corner of a building are completely destroyed at ground level.

This volume is evidently not intended for students obtaining their first qualifications in the field of structural engineering, but is directed more to those with a wider interest in the subject. To some extent the book forms a guide and commentary on the reasons for the various changes which have been made successively in connection with British Standards, the Code of Practice, L.C.C. Regulations, etc. The subject-matter is handled in a very readable style and forms a continuous story throughout the volume, which should be known to those interested in the design of modern steel-framed structures. A reading of this volume on elastic behaviour will also form the proper introduction to the second volume on plastic behaviour wherein recent research work, for which Professor Baker has been largely responsible, is to be described.

Highway Engineering. By LAURENCE I. HEWES and CLARKSON H. OGLESBY. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (8 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (64*s.*)

Professor Gilbert Murray has remarked that one does not come to understand a civilisation from the study of its literature until one knows the things about that civilisation that are so taken for granted that they are never written down.

Highway Engineering was written largely as a text-book for college courses in the United States. Such a book written for British students before the war would probably have confined itself fairly narrowly to road materials and methods of road construction, together with such other associated matters as drainage, embankments and slips, retaining walls, soil compaction and stabilisation. This book deals with all such matters in short meaty chapters which contain the essential information as well as well-chosen references to American literature which will help the student to study further. Several of the more important British books and articles have also been included and the references in general have obviously been compiled from a systematic survey of the relevant technical literature right up to the time of going to press. It takes a far wider sweep, however, than the usual pre-war British text-book because it has been written with a different basic outlook. The author insists that it is the duty of the engineers responsible for a community's roads to find out how the roads are used and where new construction is most needed.

To this end the book contains chapters dealing with planning surveys, with the computation of the benefits of highway improvements and new construction, with the various methods of financing such works and with the special problems arising from the development of towns. Data are also given on the traffic capacity of various types of road and on the design of rural roads with gradients and sight distances to permit reasonably high safe speeds.

Throughout the book the author assumes that adequate funds for road works will be placed at the disposal of the road engineer, and that, particularly in towns and on main highways, it is reasonable to undertake bridging and other works of considerable magnitude and complexity to facilitate the flow of traffic.

To sum up, this is an excellent basic text-book for the American road engineering student. The material is well written and attractively presented and the authors have been at some pains to make every section up-to-date. It is valuable also to colonial engineers, since the colonies and the United States have the same problems of constructing immense mileages of roads at low cost. Its appearance is very timely since President Eisenhower has in hand proposals to Congress for a plan of intensive road development during the next ten years to cost slightly more than 100,000 million dollars, the aim being to provide a properly articulated highway system that will solve the problems of modern travel for the American citizen. In its more technical aspects the book is of present value both to the advanced student and to the practising engineer in any country.

The proposals made by Mr. Boyd-Carpenter, Minister of Transport, to the House of Commons on February 2, to build motor roads from London to Yorkshire and from Preston to Birmingham, as well as a number of road improvements, are the first tangible sign of a changed official outlook as regards British roads. As these plans develop this book should also prove of considerable value to British engineers.

The Chambers of Commerce Manual, 1954–55. Published for the Association of British Chambers of Commerce by *United Trade Press, Limited, Boswell House, Gough-square, London, E.C.*4. (50*s.*)

It is often said that the value of a man in industry to-day is not what he knows but what he is able to look up when required. This rather trite remark is true only so long as the necessary reference books are to hand and, moreover, that the number of reference books required to cover the inquiries reaching any particular man can be kept to a reasonably small number. Engineers are familiar with this approach as the numerous "pocket" books and "year" books testify. Nevertheless the engineer's problems to-day, once he gets clear of the classroom and the drawing board, are rarely limited to purely technical matters, and the administrative problems likely to be met require that handbooks on more commercial subjects shall be available. Such a book is the *Chambers of Commerce Manual*.

This new manual, the first of its kind to be produced by the Association of British Chambers of Commerce, takes about 650 pages to bring together information on such subjects as commercial law, taxation, banking, export and import facilities and regulations, information on the organisation of the nationalised industries such as the National Coal Board and the British Transport Commission, and a section dealing with the constitution and government of the Commonwealth and empire territories. Within the limits of the space available a large number of facts and figures on a very broad range of subjects have been packed into this manual: names and addresses of authorities (including the names of the principal officers); significant clauses and regulations from the law relating to companies; current taxation as it affects companies, partnerships and individuals; export and import statistics. Only in a few places is the information represented in that form which appeals most to engineers—graphically—but in the cases where graphs are appropriate they have been used. As far as seems possible, data and figures have been tabulated, and the manual is presented in a succession of numbered parts, chapters and sections with adequate titling and side heading, an arrangement which makes it easy to find the subject matter sought. A short glossary and a fairly comprehensive index also assist in the use of the manual. For those cases where more information is required than is to be found in the manual, addresses of the local Chambers are given where further assistance may be obtained.

Although many engineers may feel that commercial and legal issues are outside their province, it is the case that many problems are determined by these aspects, often—as they will be only too well aware—without much regard to technical matters. Although written primarily for the ordinary business man rather than for the engineer, this new manual will help the latter to find an answer to many of the commercial problems encountered to-day.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Structural Analysis: The Solution of Statically Indeterminate Structures. By W. FISHER CASSIE. Second edition. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.*1. (18*s.*)

This book has been writtten particularly for the student at a university or technical college taking a degree with " Structures " as a final paper, or who is contemplating the corporate membership examination of one of the professional institutions. It is assumed that the student is familiar with basic methods of determining forces, shears, moments and deflections and of drawing influence lines for statically determinate structures; an elementary familiarity with the calculus is also assumed. Using a series of worked examples, the book illustrates the methods appropriate to each type of problem and aims to assist the reader in grasping the solution of problems more involved than he is likely to encounter in his student work.

City of Birmingham Abstract of Statistics, No. 3: 1952-1954. Edited by RICHARD PADLEY and A. B. NEALE. *Central Statistical Office, 11 Cambridge-street, Birmingham.* (10*s.* 6*d.*)

The aim of this publication is to bring within one pair of covers all available statistical material relevant to the city's progress with the exception of that relating to finance. The subjects covered include transport, communication and water supply, employment, industry and trade, and meteorology. The information is given in tabular form, and there are a number of maps.

Electrical Equipment in Mines. Edited by H. COTTON. *George Newnes, Limited. Tower House, Southampton-street, London, W.C.*2. (50*s.*)

Between 1912 and 1954 the total horse-power of the electric motors installed in British mines rose from 320,000 h.p. to well over ten times that amount. During the same period the design of the machines, control equipment and safety devices for use in mines was also improved, and a survey of the corresponding development is the main subject matter of this book. Power supply switchgear, cables, coal-cutters, conveyors, pumps, winders, haulage, signalling and lighting are all dealt with, each chapter being written by a specialist and illustrated with photographs and drawings. The treatment is descriptive and the book is intended both for mining engineers and students.

The Non-Ferrous Metal Industry in Europe. *Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris, 16e.* (500 francs); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (10*s.*)

This report constitutes one of a series of studies on the general economic situation in Western Europe carried out by the technical committees of the O.E.E.C. A review is given of short and long-term trends in the production, consumption and prices of non-ferrous metals based on conditions obtaining during 1953 and 1954. The main emphasis is laid on the question of prices and the need for greater price stability.

Proceedings of the Third International Symposium on the Chemistry of Cement. *Cement and Concrete Association, 52 Grosvenor-gardens, London, S.W.*1. (60*s.*)

The Third International Symposium on the Chemistry of Cement was held in London in 1952 and the proceedings contain in a single volume the 22 papers which were presented, as well as the 100 and more contributions made during the ensuing discussion which followed the main papers. The Symposium was held under the joint sponsorship of the Building Research Station of the Department of Scientific and Industrial Research and the Cement and Concrete Association. The range of subjects covered includes the properties of various types of cement, cements for special purposes, cement-manufacturing techniques, and the early history of cement in England.

Technical Reports of the British Electrical and Allied Industries Research Association. *Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey:—*

Behaviour of Cellulose Acetate Films under Tropical Conditions. By N. J. L. MEGSON. No. A/T141. (27*s.*) Cellulose acetate films, of varying acetyl contents and containing a range of known plasticisers, were made up under standard conditions. The films were exposed to artificial and natural tropical conditions. The effect of such conditions was assessed by observations of mould growth formation, together with changes in visual appearance, electrical and mechanical properties, and chemical composition.

Air-Blast Circuit Breakers: A Statistical Study of the Variation in Performance in Repeat Tests of a Single Break Experimental Unit with Axial Blast. By F. OLIVER MASON. No. G/T288. (10*s.* 6*d.*) This report continues the study of variation in repeat tests experienced with an experimental air-blast breaker at the E.R.A. laboratory, and describes the form of distribution obtained from a large number of tests at blast pressures below the working pressure for the circuit in question.

The Effect of Series Resistance on the Characteristics of Capacitive Spark Discharges. By H. G. RIDDLESTONE. No. G/T293. (10*s.* 6*d.*) Work described in G/T253 and G/T278 has been continued. A new technique of measurement using a potential divider has enabled discharge characteristics and energies to be measured over a range of circuit resistance up to 38,000 ohms and for discharges with durations as short as 8×10^{-8} sec.

Altitude Correction Factors for Sparkover Voltages of Insulators and Rod Gaps. By A. MORRIS THOMAS. No. L/T311. (10*s.* 6*d.*) Altitude correction factors for sparkover voltages of insulators and rod gaps involve the variation of density of the atmosphere with altitude and sparkover voltage as a function of air density. It is shown that sparkover voltage is not directly proportional to air density; a 0·75 power law provides a basis for the estimation of altitude correction factors.

Nomograms and Line Charts for Humidity Correction Factors Applicable to Flashover Tests on Insulators. By A. MORRIS THOMAS. No. L/T313. (6*s.*) Nomograms for converting readings, taken direct from the four common methods of relative humidity determination, to correction factors for humidity when doing flashover tests on insulators.

Blowing of Fuses in Distribution Systems during Thunderstorms. By J. L. MILLER. No. S/T61. (6*s.*) The blowing of fuses under lightning conditions is known to constitute a major source of trouble in distribution systems. The present report summarises the published information available and examines in detail the various probable causes to which fuse blowing may be due.

3-Pole Circuit Breakers, Circuit Interrupters, and Safety Switches. U.S. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration, Industrial and Technical Assistance Division, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management, 8 Hill-street, London, W.*1. (5*s.*)

Case study data to assist the production engineer in factories producing circuit-breakers, circuit interrupters and safety switches; the best method of using the data is given at the beginning of the report, which gives in detail the parts and methods of assembly of the production units. One chapter covers labour problems in this industry.

Third International Conference on Hot Dip Galvanizing held at Oxford, July 4-9, 1954. *Zinc Development Association, Lincoln House, Turl-street, Oxford.* (42*s.*)

The procedings of the first and second International Conferences on Hot Dip Galvanizing, held in Copenhagen in 1950 and at Düsseldorf in 1952, have been published, and now " An Edited Account of the Proceedings " at the third international conference, organised by the Zinc Development Association and the Hot Dip Galvanizers Association, and held at Oxford in July, 1954, has made its appearance. The subjects dealt with in the 17 papers, presented by authors from six European and American countries, have been arranged in 12 chapters. The discussions are now set out in logical order and their value has been enhanced by the inclusion of written contributions.

The Resources and Development of the Murray Valley. In two volumes. Report of the Murray Valley Resources Survey Committee. Issued by the Department of National Development, Australia. *The Accountant, Commonwealth of Australia, Australia House, Strand, London, W.C.*2. (63*s.*)

A committee set up by the Australian Government and the interested States has surveyed the resources and development, both realised and potential, of the Murray valley. The first volume describes natural resources, land use, and primary and secondary industries of the region; chapters also cover electricity, transport, education, health services, tourist attractions and local government. There are appendices on production statistics, and an extensive bibliography. The second volume contains 38 maps in colour and a gazetteer of 2,000 names; the maps show natural resources, climatic data, land use and services such as electricity supply, health services and postal services.

Production Control. By J. MOTTERHAM. *Department of Industrial Administration, College of Technology, Suffolk-street, Birmingham,* 1. (3*s.*)

This booklet is intended for students taking an industrial administration course. It sets out quite simply the aims and objects of production control and describes its organisation and bases. Timing, programming and stock control are also included. The booklet has been written in relation to " The Foreman and Production Control," published by the Institute of Industrial Supervisors.

Electrode Potentials and the Dissolution of Gold. By G. THOMAS. Technical Paper No. 9. *Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada.* (25 cents.)

The author is a scientific officer in the Division of Mineral Dressing and Process Metallurgy of the Department's Mines Branch, Ottawa. He states that the use of electrode potentials for measuring the activity of cyanide solutions as solvents for gold has frequently been advocated. He adds, however, that, experimentally, the potential of a metal electrode in cyanide solutions has been found to depend not only on the cyanide concentration but also on the *p*H value, on the amounts of dissolved gold or silver and oxygen present, and also on the presence of salts frequently found in cyanide-mill solutions. The author, accordingly, concludes that the potential of a gold electrode cannot be unambiguously related to the activity or the dissolving power of the cyanide solution for gold.

Strength and Resistance of Metals. By JOHN M. LESSELLS. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York* 16, *N.Y., U.S.A.* (10 dols.); and *Chapman and Hall, Limited,* 37 *Essex-street, London, W.C.*2. (80*s.*)

The aim of the author, an emeritus associate professor of mechanical engineering at the Massachusetts Institute of Technology, is to provide senior and graduate students as well as design engineers with data on the behaviour of metals, mainly steels, under stress, as they have been recorded by numerous investigators in the United States and Europe. The subjects dealt with include tension, the elastic-stage modification, tensile properties at elevated temperatures, hardness, impact testing, fatigue, and mechanical wear. A series of " examination questions " or, as the author terms them, illustrative problems bearing on the subject matter of each chapter, are given at the end of the book.

Industrial Water Resources of Canada: Upper St. Lawrence River-Central Great Lakes Drainage Basin in Canada. By J. F. J. THOMAS. Water Survey Report No. 3. *Department of Mines and Technical Surveys, Mines Branch, Industrial Minerals Division, Ottawa, Canada.* (1·50 dols.)

This is the third in a series of reports which give in detail the results of investigations into the chemical quality of waters available for industrial use in Canada. In particular, it deals with the central portion of the extensive St. Lawrence River-Great Lakes system in Canada; Part I of the report tabulates the results of monthly samplings and spot samplings of surface waters in this area, and Part 2 tabulates the analytical data on municipal water supplies within the basin and includes information on the operation of the various systems. It has been found that the further expansion of population and industry in certain areas is now dependent upon securing an adequate water supply; many industries in these areas are using hard well waters or contaminated surface waters both of which require costly treatment, and ways and means are being considered of bringing the surface waters of the Great Lakes to such areas.

Diesel Engine Operation and Maintenance. By V. L. MALEEV. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York* 36, *N.Y., U.S.A.* (6·50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.*4. (46*s.* 6*d.*)

The principles on which Diesel engines work are described for those who have a limited theoretical background. Construction, operation and maintenance of Diesel engines are covered in detail, together with sections on faults which are likely to occur and how they can be overcome. The book aims to give the Diesel-engine user a comprehensive theoretical understanding in a practical way.

The Chambers of Commerce Manual, 1954-55. Published for the Association of British Chambers of Commerce by *United Trade Press, Limited, Boswell House, Gough-square, London, E.C.*4. (50*s.*) (Reviewed on page 265).

TRADE PUBLICATIONS

Digital Computer. ELLIOTT BROTHERS (LONDON) LTD., Computing Machine Division, Elstree-way, Boreham Wood, Herts. Elliott "402" electronic digital computer containing 223 plug-in units, 13 ft. by 2 ft. by 7 ft. high, weighing 22 cwt.; standard model for such operations as data processing, evaluation of trajectories, calculation of strain in structures, lens-design computations, and tabulation of mathematical functions; instructions fed on punched paper tape into computer where they are represented by sets of electrical pulses in terms of binary scale; output: by external electric typewriter, or tape perforator and page-printer; power requirements: 8 kVA, 415 v, 50 c/s, three-phase with neutral and earth. Claimed by makers to perform in one hour more than can be completed in two years by operator using conventional methods. Illustrated booklet.

Incandescent Nitrogen Generators. THE INCANDESCENT HEAT CO., LTD., Cornwall-road, Smethwick, Birmingham. "Hi-Nitrogen" self-contained combustion-type generator units for production of nitrogen from mixture of air and fuel gas (town gas, clean producer gas, water gas or coke-oven gas). Product gases range from 99 per cent. pure nitrogen to mixtures containing either excess oxygen or excess combustibles up to 6 per cent. In the process, heat of combustion is used for reactivation of carbon-dioxide absorbent and the gas, which is dried by an activated-alumina drying unit, is delivered with a dewpoint of −30 deg. F. Plants made in standard sizes ranging in capacity from 500 to 20,000 cub. ft. per hour. Illustrated leaflet.

Speed-Reducing Gears. SANDERSON BROTHERS AND NEWBOULD LTD., P.O. Box No. 6, Newhall-road, Sheffield, 9. "Heliocentric" speed-reducing gears based on principle whereby eccentrics on input shaft lift successively radial plungers carried by output shaft; the rising plungers make sliding contact with the teeth of a stationary circular rack fixed to the unit casing, and are thus driven sideways, so imparting a rotary motion to the plunger assembly; the input and output shafts and the rack are concentric. Heliocentric reducers are made with reduction ratios ranging from 20 : 1 to 512,000 : 1 (triple stage unit). Illustrated booklet giving principles of operation and construction, applications, and torque and dimension tables.

Furnace and Stove Insulation. STILLITE PRODUCTS LTD., 15 Whitehall, London, S.W.1. "Therbloc" lightweight insulating slab of resilient texture made from "Stillite" mineral wool; also acts as acoustic insulator. Fusion temperature: 2,372 deg. F., thermal conductivity for mean temperature of 572 deg. F.: 0·60 B.Th.U. per sq. ft. per hour per inch thickness per deg. F. temperature difference, with hot face temperature 1,065 deg. F. and cold face 79 deg. F. Leaflet with graphs and tables.

Recording X-Ray Diffractometer. HILGER AND WATTS LTD., 98 St. Pancras-way, London, N.W.1. Instrument for the investigation of crystalline substances by X-ray diffraction methods. Results are shown by a pen record on a chart without employing photographic processes. Booklet giving illustrated description of apparatus and containing reproductions of charts.

Barrel Finishing. LACRINOID PRODUCTS LTD., Gidea Park, Essex. "Lacromatic" barrel-finishing process for metal articles; finishes from scaling to burnishing; process based on "Lacron" mineral oxide chips and range of "Lacron" complementary compounds. Character and properties of chips and compounds. Illustrated booklet.

25 Years of Fluidrive. FLUIDRIVE ENGINEERING CO., LTD., Worton-road, Isleworth, Middlesex. "Fluidrive News" special issue (January, 1955, Number 220) to commemorate company's 25th anniversary. Also illustrated leaflets depicting application of Fluidrive (Vulcan-Sinclair) fluid couplings to electric motors and internal-combustion engines.

Motors to Anglo-American Standards. LANCASHIRE DYNAMO AND CRYPTO LTD., St. Stephen's House, Victoria-embankment, London, S.W.1. Electric motors (1 to 30 h.p.) with outputs and dimensions common to British, American and Canadian standards. Leaflets Nos. ML.79 and B.15.

Biased Induction Relay. A. REYROLLE & CO., LTD., Hebburn, Co. Durham. Type TJG biased induction relay for differential protection schemes. Single or triple pole models. Pamphlet 1213 gives operating and constructional details.

Lorry Loader for Drums. POWELL & CO., Burry Port, Carmarthenshire, South Wales. "Skid Master" mobile lorry loader, hand operated, for drums or barrels up to about 7 cwt., up to heights of 4 ft. 6 in. Illustrated leaflet.

The Engineering Outlook—8

LIGHT ELECTRICAL AND CABLE INDUSTRIES

AN OUTSTANDING YEAR

The year 1954 was outstanding for the light electrical industry, whether it is measured by the volume of sales or the new technical ideas which reached a stage where they could make some commercial impact. Most companies making light electrical goods are enjoying excellent trading conditions. The final impetus to success has been given by the boom in consumer goods which has developed since the summer, and which promises to continue for some time at least. The picture in export markets, however, is decidedly more varied. Experience ranges from record sales of radio transmission equipment of all kinds to a severe fall in sales of industrial refrigeration equipment. In cable manufacture, the industry has suffered to some extent from the uncertainties generated by the report of the Monopolies Commission and from a number of factors which have resulted in a decline in export business.

So far as domestic electrical appliances are concerned, the graphs given herewith, Figs. 1 and 2, are eloquent of boom conditions. Electric vacuum cleaners and electric irons sold in larger quantities in the domestic market last year than in any of the previous three, and export turnover as well was moving up steadily in the direction of the high figures reached during 1951. A similar upward surge can be seen in Fig. 3 which shows the trend of production in electric washing machines and electric cookers.

During 1954, makers of the larger domestic appliances, such as washing machines, refrigerators, electric cookers and vacuum cleaners, were faced with the prospect of both higher costs and a shortage of materials. The wage award last year was a serious threat to an industry which was already burdened with 50 per cent. purchase tax. The outstanding example of this combination of problems was in electric cookers where prices had been reduced in 1953 but had to be raised again by between 7½ and 10 per cent. owing to increased labour costs. The shortage of deep-drawn steel sheet was also acute in this case.

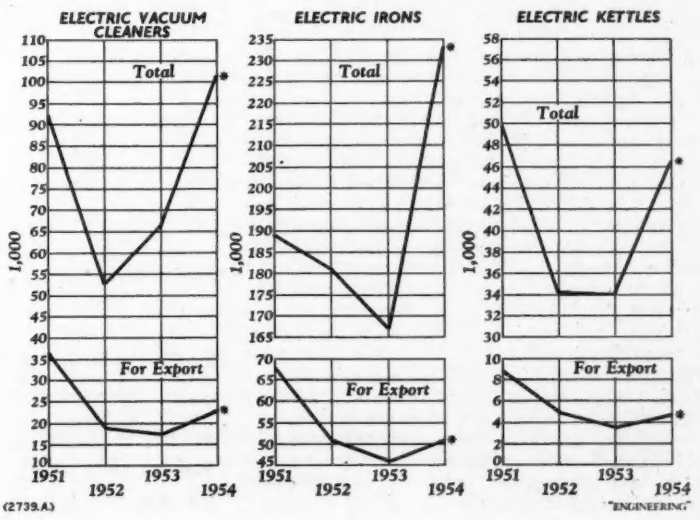
The light electrical goods industry had about reached the position, by mid-year where the best prospects were for those large engineering firms which could inerease their productivity and bolster their sales by large advertising appropriations, following up their sales drives with the continued build-up of a maintenance service through an accredited agent or dealer, and so avoiding wholesale charges.

In contrast, the refrigerator industry was able to reduce its prices without giving the suggestion that further price concessions would be forthcoming, and the general impression was created throughout the year that refrigerator prices had reached a point of stability. The result was that sales of refrigerators increased substantially, as can be seen from Fig. 4. Only industrial refrigerators have shown any tendency not to move in sympathy with the boom conditions of the last nine months. It is probable that refrigerator sales could have built up even more rapidly had there been sufficient steel available to the manufacturers.

This was the general picture in July last year when hire purchase restrictions were removed. In consequence thereof, on top of the increased purchasing power which the public were enjoying as a result of the industrial recovery, there were then added the orders created by the relaxed hire purchase facilities. The consequence has been a boom in all kinds of domestic electrical appliances which has carried on into 1955. The reimposition of hire purchase restrictions last week will probably slow down the rate of increase of sales arising from this source but it is not likely to bring their growth to a halt, for as the public's purchasing power increases so does their tendency to seek hire purchase facilities for durable domestic goods. The industries concerned are much more likely to find their activities curtailed by a shortage of steel than by a shortage of orders.

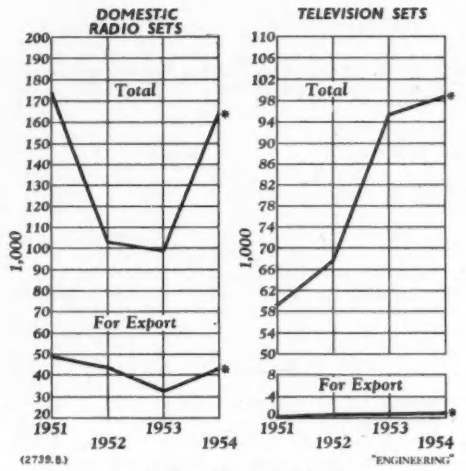
CONSIDERABLE ELECTRONIC PROGRESS

Although the sale of domestic radio sets has recovered sharply in the last 12 months, accompanied by a rapid increase in the sale of television sets, the tendency for the electronics industry to diversify its interests towards the instrumentation field has continued. Progress is still being made in the installation, both in this country and abroad, of British electronic equipment as navigational aids. Recent mishaps to ships in home waters when using radar have shown the need for increased skill in the use of such equipment, but this aspect of the electronic industry has now firmly established itself commercially. Sir Robert Renwick, the president of the Radio and Electronic Component Federation last year, was able to say "that Britain is the greatest exporter of loose components in the world." He pointed out that this country is now making nearly 3 million radio components a day and exporting half of them. Between



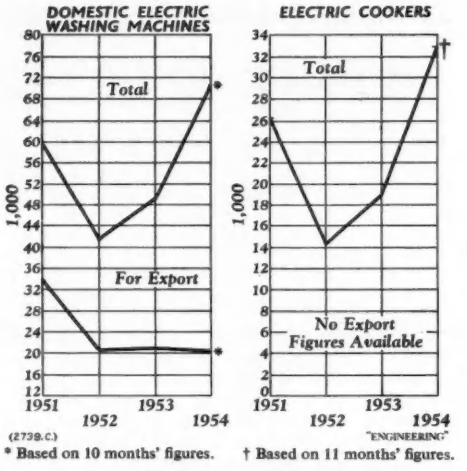
* Based on 9 months' figures.

Fig. 1 Domestic electrical appliances made in the United Kingdom during the last four years (monthly averages).



* Based on 11 months' figures.

Fig. 2 Radio and television sets (monthly averages).



* Based on 10 months' figures. † Based on 11 months' figures.

Fig. 3 Domestic electric washing machines and cookers (monthly averages).

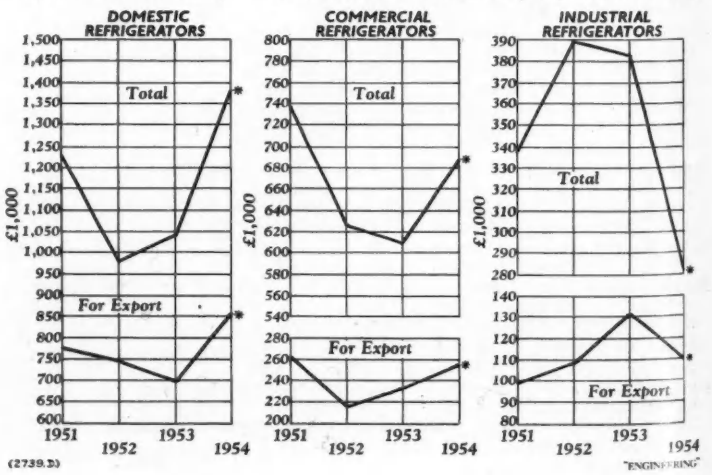
1952 and 1954 the export of radio, television, radar and sound producing apparatus increased from £23 million to £26 million and, of these, radio communication and navigational aid equipment in a completely assembled form advanced from £7·4 million to £11·7 million.

The last year has been a notable period of technical advance in radio, both in sound broadcasting and in television. It was also a time of second and more sober thoughts on certain technical problems, notably on colour television. The year opened with the first serious doubts from across the Atlantic about the immediate prospects of colour television, and before the year was out the Director General of the B.B.C. was saying, with the technological support of the British radio industry and in the light of the bitter commercial experience of its opposite number in the United States, that colour television would not be a commercial proposition for two or three years yet. Even the United States finds colour television on a 14-in. tube expensive at £300 a set. The quest continues for a large tube which can be produced at a price attractive enough for the public both in this country and abroad. It is generally agreed that it is only a question of time before the considerable amount of research expended on the development of colour television, which of course has been amply proved on special but expensive sets, comes within the purchasing capacity of the general public.

In spite of the vindication of the more conservative school of thought on colour reception, and it would be putting the matter too strongly to speak of a setback, the last year or so has been one of great advance in British television. In addition to the ever-widening public now in possession of receiving sets, the first moves were made to establish the Independent Television Authority which will soon offer the viewing public alternative programmes to the B.B.C. Sponsored broadcasting and the end of the monopoly of the B.B.C. are now realities. How severe the resulting competition may be does not concern us here. It is apparent, however, that developments of this kind must mean an expansion in all kinds of television transmitting equipment.

The stimulus which an increase in television services can mean is illustrated by the eight-nation T.V. link-up last June, which lasted for four weeks and involved the use of £2 million worth of equipment, most of it British. On this occasion Pye, Limited, supplied two studios to Belgium, an outside broadcasting unit to Denmark and camera equipment to Switzerland, France and Germany. Marconi's Wireless Telegraph Company, Limited, provided four microwave links to Denmark, and sound and vision transmitters to Italy. Electrical and Musical Industries, Limited, supplied film scanners to Italy and microwave links to Switzerland; British Insulated Callender's Cables, Limited, sold cables and couplers to France, Holland and Italy, and the General Electric Company, Limited, provided microwave links in France, Italy and Switzerland. In addition, Standard Telephones and Cables, Limited, were responsible for two radio links in Holland. The general stimulus to sales of transmitting apparatus overseas which the growth of broadcasting throughout the world has brought about can be seen in Table I where transmitting apparatus has increased from £7·9 million to £12·4 million a year in two years.

While public attention inevitably becomes centred on developments in television, sound broadcasting continues to be improved in ways which are bound to benefit radio manufacturers. Within the last 12 months very high frequency (V.H.F.) has been approved. The B.B.C. had intended improving the inadequate services offered in certain areas on long and medium wavelengths by erecting 50 transmitters on 20 separate sites to put out V.H.F. transmissions. In the event, approval was given early last year for a programme of nine stations instead of 20, and it is expected that even this revised programme will not be completed before the end of this year. V.H.F. should help sound broadcasting to hold its popularity longer than would otherwise be the case, for it should increase the quality of reception in areas which have long suffered from inferior services in this respect. Once V.H.F. is completely installed, manufacturers will have to adjust the design of their sets accordingly, but existing models will not be obsolete. It seems probable that the effect on production policy will be for the cheaper radio sets to dispense with the present short-wave band and install a V.H.F. selector, while the more expensive sets will have a short-wave range as well as V.H.F. One of the most important consequences of V.H.F. (and of the more ambitious T.V. link-ups which have been tried out, such as the inter-European one last June) should be the stimulation of the production of special valves.



* Based on 11 months' figures.

Fig. 4 Production of various types of refrigerators in the United Kingdom since 1951 (monthly averages).

TABLE I. *United Kingdom Exports of Light Electrical Goods and Apparatus*

—	Value (£1,000)		
	1952	1953	1954
Wireless apparatus:			
Domestic radio-receivers	4,436	3,513	3,178
Television receiving sets	195	428	450
Transmitting apparatus ..	7,963	11,049	12,396
Valves, complete ..	3,615	2,200	2,113
Telephone and telegraph apparatus	17,015	17,348	15,716
Electric-light bulbs, complete	1,359	1,085	1,287
Electric-light appliances and accessories	5,177	4,887	4,702
Batteries, primary, complete	2,251	2,251	3,098
Accumulators	4,597	3,107	3,197
Electrical cooking and heating appliances	4,086	2,704	3,916
Electrical instruments ..	3,399	2,834	3,276
Electro-medical apparatus ..	1,283	1,221	1,113
Refrigerating machinery ..	14,113	12,874	15,262
Vacuum cleaners, complete	1,912	1,500	2,032
Total	71,401	67,001	71,736

SEMI-CONDUCTOR DEVELOPMENTS

One of the largest electrical equipment manufacturers in the country has announced within the last year that their work on semi-conductor research now represents their second largest development project. This is some indication of the importance which is now attached to these developments, one of which is the transistor. It has been claimed that the development of this device will prove to be the most significant advance in radio and electronics since the invention of the thermionic valve. It seems probable that the most rapid and significant applications for these " crystal valves " will be in the tele-communications field. So far as domestic radio and television receivers are concerned, the earliest uses are likely to be in personal or small portable radio sets which will give performances equal to present valve receivers but will require only one-tenth of the power to operate them. It is unlikely that developments in the transistor will have a major impact on the design of television receivers for some time.

The immediate field for the present semi-conductor devices which have been developed is in electronic equipment where small size, lightness in weight, long life, strength, reliability and low power consumption are important. One possible development arising out of the transistor is likely to be the increased use of dry batteries. The small currents at low voltage required by transistors can be very well supplied by batteries of this kind, and there may be a field here, ranging from hearing aids to complex radio equipment, to be developed in the near future.

In the field of tele-communications the delivery of telephone equipment to the home market continues to be limited by the capital expenditure restrictions imposed on the General Post Office. The number of subscribers waiting for telephones is now down to about 375,000, which is only

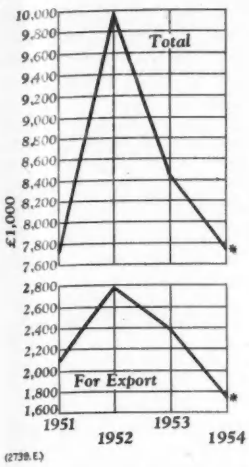


Fig. 5 Electric wires and cables made in the United Kingdom since 1951 (monthly averages).

* Based on 9 months' figures.

about 25,000 less than in the previous year. As fast as the front of the queue is dealt with, it grows at the back, and on recent performance the Post Office has been less successful in reducing the length than it was, say, two years ago. Abroad, competition continues to be keen, and there have been appeals during the year for the extension of credit facilities to customers in order to improve this country's competitive position against Germany and the United States. It will be noticed from Table I that exports of telephone and telegraph apparatus were down by 9 per cent. last year compared with 1953, but even so they remain the largest item in a total of light electrical goods and apparatus exported abroad which came to nearly £72 million in 1954.

HEAVY CABLE PROBLEMS

Recent experience in the heavy cable side of the tele-communications industry has been exceedingly mixed. It is hoped that considerable technical stimulus will be given by the £12·5 million submarine telephone cable which is now being manufactured for the North Atlantic tele-communications service. On the commercial side, however, the industry has suffered from a number of complications both abroad and at home. Table II records a severe decline in the volume and value of exports of electric wires and cables. About half of this is accounted for in the decline in exports of heavy cables, and there is no doubt that this side of the industry in particular has encountered increasingly severe foreign compeition. This problem has been made worse for the industry by the behaviour of base metal commodities, notably copper, which at various times in the last 12 months has behaved as if a price reduction was likely to develop. Customers have therefore been inclined to delay placing orders, although in the event their expectations of lower prices have not been borne out.

At home, the industry has suffered from the consequences of the report by the Monopolies Commission. Following the Government's endorsement of the Commission's recommendations that certain practices in the industry should be discontinued, there have been signs of price cutting, and although those outside the industry would doubtless welcome an increased element of competition among cable makers, there is no doubt that the disturbance which such an possibility brings with it could not have occurred at a more awkward time for the industry's general outlook. The industry certainly faces a difficult period. There can be little hope that raw material costs will fall significantly, turnover in the home market is severely limited by the carefully scheduled programmes of Government departments and nationalised industries, and the export market is likely to remain difficult to hold against other countries exporting cable.

It would be wrong, however, to assess the heavy cable makers' prospects only in terms of immediate problems. The fact that the uses of cable are becoming increasingly allied with radio communication of various kinds is an indication that the general outlook for cables is going to be affected from now on by developments in television and radio broadcasting where international link-ups are becoming an increasing feature of national programmes. It is inevitable that the cable industry should be commercially and technically stimulated by such developments, and reference has already been made to the inter-European link-up carried out in June, 1954. In addition to this, the new transatlantic cable may well herald increasing attention by technicians to the possible applications of submarine cables to a variety of radio work. The growing need for traffic capacity, the dependability of cables, their privacy and the opportunity they give for boosting signals through repeaters, suggest that, although cables may not recover the lead which radio transmission has established, they may take an increasing share in the development of inter-continental communications in the future.

In contrast to heavy cables, the export record of rubber insulated cables in 1954 was better than many might have dared to hope. Shipments were down by only 13 per cent. This compares, however, with a decline of only 6 per cent. in 1953, and it may well be that the process of contraction in exports of light cables will go on for some time until they find a new level. The tendency, which has been referred to in past years in this series of articles, for local factories to become established where exporting countries had at one time built up flourishing connections, seems likely to go on for some time. The decline, however, is likely to be of degree rather than the eclipse of the market. As long as British manufacturers can establish local subsidiaries themselves and can compete on a quality basis, they should be able to retain a worthwhile foothold in overseas markets.

TABLE II. United Kingdom Exports of Electric Wires and Cables

	Quantity (Tons)			Value (£1,000)		
	1952	1953	1954	1952	1953	1954
To Nigeria	901	1,596	956	328	469	279
„ Union of South Africa	8,538	7,366	3,976	2,918	2,677	1,393
„ Northern Rhodesia	809	951	487	264	238	130
„ Southern Rhodesia	1,963	1,390	745	671	426	243
„ Kenya	1,933	1,253	1,064	612	404	255
„ Kuwait	982	1,343	1,477	296	432	398
„ India	18,022	17,466	10,885	5,026	5,041	2,705
„ Pakistan	3,188	2,497	3,956	1,020	720	1,085
„ Singapore	3,158	2,709	4,093	998	791	834
„ Federation of Malaya	1,404	1,948	1,960	490	580	571
„ Ceylon	844	1,525	551	328	432	201
„ Hong Kong	2,216	1,751	1,526	798	582	451
„ Australia	9,577	7,837	4,734	2,833	2,301	1,391
„ New Zealand	7,687	8,063	5,696	2,713	2,427	1,609
„ Canada	2,213	2,999	1,482	584	713	429
„ Trinidad	415	482	395	174	169	143
„ Other Commonwealth countries	7,082	11,384	7,671	2,158	3,221	2,174
„ Irish Republic	2,922	1,394	1,090	1,036	499	393
„ Finland	1,219	93	16	424	45	15
„ Sweden	1,704	133	108	603	102	77
„ Norway	487	1,164	483	156	285	126
„ Denmark	332	134	374	133	81	166
„ Netherlands	737	341	596	230	150	246
„ Portugal	917	572	889	342	200	273
„ Austria	667	179	533	203	49	136
„ Greece	1,489	417	554	449	134	184
„ Roumania	1,322	3,387	143	409	1,056	39
„ Turkey	2,869	1,183	179	920	360	48
„ Israel	631	669	280	198	220	35
„ Egypt	1,208	348	221	349	121	77
„ Iraq	1,605	2,618	1,345	503	703	355
„ Iran	65	26	77	21	12	12
„ Burma	613	629	918	260	226	289
„ United States of America	43	293	93	31	70	36
„ Cuba	786	106	73	275	36	23
„ Mexico	750	57	173	238	16	50
„ Colombia	744	307	1,685	281	108	439
„ Venezuela	1,394	1,121	1,499	564	382	463
„ Peru	235	305	123	96	100	41
„ Brazil	458	279	5	185	83	4
„ Argentine Republic	422	124	55	163	77	40
„ Other Foreign countries	5,014	10,943	5,284	1,889	2,892	1,534
Telegraph and telephone cables and wires:						
Submarine	4,708	4,887	4,728	725	921	759
Other	26,328	26,284	13,936	8,239	7,866	3,812
Other descriptions:						
Cotton, silk or artificial silk insulated	1,690	1,306	889	885	665	439
Enamel, glass or asbestos insulated	1,562	1,576	1,671	935	976	874
Paper insulated	42,963	45,928	28,024	10,597	11,071	6,121
Rubber insulated	16,052	12,977	13,475	7,465	5,005	4,649
Other	6,262	6,424	5,727	3,323	3,126	2,738
Total	99,565	99,382	68,450	32,169	29,630	19,392

★ ★ ★

PROTECTION OF MOTOR CARS FOR EXPORT

The Problem of Deterioration During Shipment

The shipment of motor cars for export, either assembled or as "completely knocked-down" sets of components and assemblies, presents deterioration problems quite different from those encountered during service on the road. Mr. E. A. Shipley, speaking on "Deterioration of Motor Cars During Shipment Overseas," to the North-East Coast Institution of Engineers and Shipbuilders at Newcastle on February 25, said that the need for investigation became acute in 1949-51, when large numbers of cars were found to be affected by mould and blistering on arrival overseas. The worst damage occurred on complete vehicles; those sent "C.K.D." were easier to protect. Protection of a complete vehicle was more difficult, though it is interesting to note that experimental enclosure of a vehicle in a polythene film, sealed, and with a silica-gel desiccant, was completely successful. Unfortunately, the high cost of this method of protection prevented its adoption.

It was decided to study the problem more fully, to investigate conditions prevailing in the holds of vessels on voyage, to make field tests on various mould inhibitors, and to examine in the laboratory the causes of paint breakdown. It was known that although a number of ships had modern air-conditioning plant, adverse conditions were developing in the holds during a voyage. A special apparatus was therefore devised to record conditions inside an individual car. It consisted of a dial thermometer, reading from 20 deg. F. to 220 deg. F., and a hygrometer reading from 20 per cent. to 100 per cent. relative humidity. These were mounted suitably, and were photographed automatically at hourly intervals by a specially-designed camera. The records showed that on a voyage to Australia relative humidities of 80 per cent. or more, and temperatures of 75 deg. F. or more could be reached. With cargoes of packed cars, temperatures recorded in holds rarely agree with the true temperatures of the vehicles, and the risk of cargo sweat is greater than would be expected from the ship's records.

Special packs were devised to provide infor-

mation on high humidity, the effect of treating the case timbers with mould inhibitors, the effect of vapour-phase and contact inhibitors inside the vehicles, the relative merits of crates and close-boarded cases, and the effect of sealing the cases. It was discovered that treatment of the case timbers had no effect on the growth of mould inside the cars, and that there was very little benefit from the use of a crate or ventilated case as distinct from a closed case. The investigation also showed that the moisture inherent in the timber may have an important effect on the degree of mould produced, and that ventilation of the hold was important.

Field tests disclosed the fact that lauryl pentachlorphenol in the form of an interior spray was ineffective as a mould inhibitor, but that furfural, a vapour-phase inhibitor, was completely successful. Furfural stains surfaces with which it comes into contact, so the further problem of a suitable dispenser arose. This has now been solved, and the treatment has been used successfully for the last 15 months. Laboratory tests on paint blistering showed that this problem is not straightforward. A promising approach was that of preventing moisture from reaching painted surfaces by coating them with protective waxes. Unfortunately, while a number of these waxes prevented blistering, subsequent removal of the coating left a paint finish which was unduly susceptible to breakdown under service conditions.

In conclusion, Mr. Shipley said that preventives and inhibitors had rendered corrosion of metal components and assemblies virtually non-existent. Mould attack of interior trim can be brought almost completely under control by the use of a suitable vapour-phase inhibitor, but the blistering of paintwork cannot be entirely eliminated by the efforts of the car manufacturer and paint maker alone. It follows that greater knowledge and better control of hold conditions will be needed before the paint blistering problem is solved. Greater use of mechanical ventilation, possibly together with air-drying equipment, might go a long way towards eliminating the conditions which cause so much trouble at present.

* * *

RUNNING-IN AN ENGINE

Interdependence of Surface Finish and Lubricating Oil

On February 8, in London, a paper entitled "The Running-in of Engines: Choice of Cylinder Bore Finish," was presented by Mr. K. R. Williams and Dr. S. G. Daniel to the Automobile Division of the Institution of Mechanical Engineers. Both authors are at the Thornton Research Centre of Shell Research, Limited, and the paper described a series of tests carried out there to determine what effects the roughness of the cylinder bore and the type of lubricating oil had on the time taken to run-in an engine. Both rig tests and engine tests were used, the engine being a single-cylinder water-cooled unit, producing 2·7 brake horse-power at 1,060 r.p.m., with a fuel consumption of 0·4 litres per brake horse-power-hour. The surface finish was measured with a Talysurf instrument.

The authors first described the rig tests, in which a cylindrical slider was passed to and fro on a flat plate. It was found that the wear of both slider and plate was profoundly influenced by the surface finish of the plate. They found also that additive oils reduced the rate of wear when the surface was smooth, but that plate wear actually increased when the surface was rougher than 10 micro-inches, centre-line average.

Although the authors realised that to achieve a particular finish involved production difficulties, they considered it a desirable aim cast-iron liners of cylinder blocks, a bore finish of some 20 to 40 micro-inches c.l.a. average roughness, in which the surface roughness has at least twice the height of the waviness, is desirable. With such a bore finish break-in will be rapid with both straight mineral oils and those containing anti-wear additives. With certain of these additives break-in may be even more rapid with the additive oil than with straight mineral lubricants. These considerations apply to engines fitted with both cast-iron and chromium-plated piston rings. For bores having a surface finish which is smoother or has more waviness than that specified above, the time for break-in to occur will be greater, and will be determined by the rate at which wear occurs and by the amount of waviness present in the surface finish. With cylinder bores of this type, break-in will be slowed down by the use of additive oils.

Although the authors realised that to achieve a particular finish involved production difficulties, they considered it a desirable aim because many modern engines were so highly rated that additive-type oils were essential for their satisfactory operation.

ENGINEERING SERVICES AT HARWELL

HAZARDS OF RADIOACTIVITY

In the course of an informal lecture which he delivered before the Measurements Section of the Institution of Electrical Engineers on Tuesday, February 15, Mr. W. E. Harris said that the use of industrial labour in buildings where radioactive substances were handled necessitated close supervision and the imposition of a high standard of health discipline. The laboratories at Harwell where research work was carried out on highly radioactive materials were called "special buildings," and in these buildings all engineering maintenance and operation personnel were under the control of one engineer. He was responsible for the operation and maintenance of engineering plant, preventing the spread of radioactivity, decontamination and cleaning, the disposal of contaminated equipment, trash and liquid by-products, the erection and installation of scientific equipment and the supply of special services, laboratory workshops, maintenance and modifications to buildings.

PROTECTIVE MATERIALS

The protection of personnel from exposure to γ-rays was achieved by using various kinds of shielding, e.g., lead, concrete, steel or water, depending on price, availability, suitability and space available. Vision through, or over, shielding was obtained by lead-glass windows, zinc bromide or water windows, reflector mirrors or closed-loop television. Work was done behind shielding with manipulators or other remote handling equipment, often designed empirically for a particular job.

The protection from α-particle emitters was more difficult. The hazardous quantities were so small that they were difficult to detect when air-borne; for example, the life-time body burden of plutonium 239 was 0·64 μg, and the maximum permissible level for a 40-hour week, if taken over the whole of a normal working life, corresponded in weight to about 10^{-4} μg per cubic metre of air. Air-borne radioactivity could not be spot-checked by radiation probes: a large quantity of air must be passed through a filter until sufficient activity was concentrated on the paper and could be measured.

Certain laboratory areas, which were entered constantly and at short notice, were treated as being probably highly contaminated, and could be used only by people dressed in pressurised suits. This necessitated the provision of dressing areas with decontamination facilities and intercommunication control. Extraction ventilation, trunking and electrostatic precipitator chambers were in the same category of probably highly-contaminated areas, and the use of pressurised suits was obligatory.

REDUCTION OF FIRE RISKS

Work on α-particle emitters was usually done in glove-boxes; these could be manufactured to take equipment of varying size from small analytical rigs to quite large machinery. Where radiation and inhalation hazards existed together it was necessary to have a glove-box within shielding, or shielding within a glove-box. Where possible it was the practice to isolate the electrical installation in a separate compartment in glove-boxes in order to reduce the fire risk. The danger of fire came mainly from overheated motors or arc faults igniting inflammable solvents. The protection of fractional horse-power motors was not simple when 100 per cent. safety was required. Small thermal cut-outs, even when reasonably accurate in operation must be fitted into the motor windings to act quickly enough to be efficacious. The electrical section of the boxes had been filled with nitrogen. The working sections of many boxes were supplied with argon, owing to the rapid oxidising characteristic of some of the radioactive materials used. A plant for the purification and recirculation of argon was used which gave results of not more, and often less, than 100 parts in 10^6 impurities.

VENTILATION

The ventilation of special buildings was made more complex because dust carried radioactivity and assisted in spreading it, so that the air must be filtered entering and leaving a building. In some buildings mechanical filters were used, those with the highest efficiency being resin-wool or asbestos-cotton packed. In other buildings, electrostatic precipitators of the parallel-plate type were used for filtering. Experience showed the efficiency of this type varied considerably. With large precipitators it was difficult to maintain an equal velocity of the air over the whole surface, and variation of velocity affected the efficiency. Penetration of precipitrons might be as high as 60 per cent. for larger sized particles. Where precipitrons were fitted in buildings at Harwell, the extraction ventilation was provided with mechanical filters in series from compartments where a high air-borne hazard was likely to exist.

The precipitator commended itself in some respects. The installation cost was high but the maintenance costs were low, although these depended on the degree of corrosion prevailing in the cells. Experience was that the cadmium-plated cell plates corroded fairly rapidly in extraction systems from laboratories.

SPECIAL BUILDINGS

Special buildings had many features, all designed to ensure a high degree of cleanliness, prevent spread of contamination and assist in easy decontamination, e.g., covings, strippable wall paints, concrete cells, lead benches. In one building alone the disposal of effluent entailed the use of 32 delay tanks and the maintenance of 60 pumps. To economise in the use of water, recirculating cooling water and water-ejector vacuum pumps had been developed.

When scientists had no further use for highly contaminated equipment they gave it to the engineer for disposal; this often presented a problem. Packaging coats and polyvinyl-chloride sheet, welded by the high-frequency welder, were widely used for this work. There was also the disposal of radioactive trash, which involved monitoring and certification.

No consideration of the work of a services engineer working with an atomic-energy project would be complete without mention of the effect of radioactivity on industrial staff. The difficulty of educating newcomers to take health precautions without supervision was ever-present. These same health precautions caused a loss of effective working time which averaged 1·64 hours per man per day.

ELECTRICAL AND MAGNETIC MEASUREMENTS*

ACCURACY INCREASED BY ELECTRONIC METHODS

By D. Edmundson, B.SC. (ENG.)†

The difficulties which arise in measuring alternating current, voltage and power, owing to the condition that the instruments shall not disturb the system being measured, can be completely overcome by using an amplifier to supply the voltmeter and the voltage coil of the wattmeter. The "load" then has a negligible influence on the current passing.

Such a wattmeter-amplifier, which might be described as an amplified cathode-follower, is of universal application. The voltage coil and feed-back resistance are connected in the cathode circuit of a valve, the grid of which is supplied by a two-stage direct-coupled amplifier. The input to this amplifier is the difference between the input voltage and the voltage drop across the feed-back resistance. The direct-current component of the cathode current of the valve is diverted through a tetrode, which is connected so that its alternating-current resistance is enhanced. In effect, this tetrode acts as a high-efficiency choke without phase-shift.

The input to a third valve is the error, and is usually about 1 millivolt for an output current of 20 milliamperes. The amplifier can be designed for inputs of 1 volt upwards and its load on the circuit is negligible. For inputs greater than 10 volts it is convenient to provide an input voltage divider, but this can also be of such high impedance that its consumption can be neglected. The circuit has the further advantage that it saturates at an overload, which is too small to damage the meter coil and thus provides automatic protection.

LIGHT POWER MEASUREMENTS

The most immediate use of the amplifier-wattmeter is for light power measurements. A milliammeter in series with the wattmeter voltage coil is calibrated to read in volts; the high-resistance voltage diverter, which supplies the coil, is connected direct across the load. Current ranges are obtained from a current transformer with a tapped primary winding. The amplifier-wattmeter, in conjunction with a backing-off mutual inductance, is also convenient for measuring low power factors for which ordinary wattmeters are unsuitable and alternating-current bridges inconvenient.

MEASUREMENT OF SPEED AND FREQUENCY

The factors which limit accuracy when a tacho-generator is used to measure speed cease to be important when the same instrument is employed to determine the frequency. The frequency meters, which are utilised for this purpose, all derive from Clerk Maxwell's commutator bridge, which he employed to measure in electromagnetic units the capacitance of a condenser in terms of a known resistance and frequency. It employed the principle that a succession of impulsive currents obtained when a capacitor C was charged n times a second, produced a mean value in a moving coil galvanometer of the same value as a resistor R, where $R = 1/nC$ — (circuit resistance measured from the capacitor terminals). The capacitor and its charging device were placed in one arm of a Wheatstone bridge. In the instruments described in the paper, Maxwell's commutator is replaced by a polarised relay and a known capacitor is used to measure an unknown frequency or speed.

The advantages of such an arrangement are that as the instruments are essentially counting devices their accuracy is not affected by waveform or voltage. When used to measure speed they can be operated by any type of alternator, by magnetic, electrostatic or photo-electric pick-ups or by mechanical contacts. Their accuracy is dependent on the values of stable components and since the range of a deflectional instrument can be as small as desired, reading accuracy can be made to match the inherent accuracy of the circuit.

In a mains-frequency meter embodying this principle, both the supply to the relay coil and the direct-current to the bridge are obtained from the voltage whose frequency is to be measured. The bridge is designed to balance at any frequency between 47 and 53 cycles by adjusting a small potentiometer. The meter is small, portable, convenient and accurate to 0·5 cycles per second. Maxwell's bridge can also be used to operate an indicating tachometer and to measure directly the slip frequency of an induction motor. In the latter case the problem of the very low frequencies concerned—from 0 to 7 cycles in ordinary 50-cycle motors up to their pull-out points—has been solved by charging the condenser by the relay and discharging it into the vacuo-junction of a thermal milliammeter once every slip cycle. The voltage to which the condenser charges is established by the striking of a stabilising tube.

GRADING TRANSFORMER STEEL

These methods are also suitable for the grading of individual sheets of transformer steel according to their specific loss. As they are non-destructive they can be used on whole sheets on the production line. The equipment comprises a conveyor belt, which passes the sheets through a flat open-ended coil. This coil consists of six sections in parallel so as to give a uniform flux density in the two central sections. Secondary coils are wound beneath the primary windings on these sections to supply the wattmeter and voltage-control circuits. The loss is measured by supplying one element of a dynamometer wattmeter from the current in the two centre primary coils, the other being fed through an amplifier from one of the secondary coils. The other secondary winding, in conjunction with the same primary current (supplied through a current transformer), controls the excitation of the alternator supplying the magnetising current through a suitable circuit. The tester has been operated continuously at speeds up to 10 sheets per minute.

DIELECTRIC MEASUREMENTS

The Carpenter relay is also employed in a B/H loop tester for general alternating-current magnetic measurements and for routine tests on nickel-iron cores. It is further used as a polarised rectifier in an instrument which has been designed for measuring power factor or loss angle directly and thus assessing the insulation of the windings of high-voltage machines and transformers. The current from the specimen is passed through a direct-current galvanometer which is shunted by the contacts of the polarised relay. The coil of the relay is supplied with current from a limiting amplifier which in turn is excited from the mains supply through a phase-shifting circuit.

* Paper read before the Measurements Section of the Institution of Electrical Engineers on Tuesday, February 1. Abridged.

† Mr. Edmundson is with the British Thomson-Houston Company.

AUTOMATIC INDEXING MACHINE

THE MEASUREMENT OF GEAR TOOTH PITCH ERRORS

By C. Timms, M.ENG., M.I.MECH.E., M.I.PROD.E., *and C. A. Scoles*

In this paper, the authors describe an automatic gear-measuring machine designed to record graphically adjacent and cumulative errors in tooth pitch. Built to save time and labour, it has been developed from an earlier Tomlinson machine and incorporates an automatic indexing gear. Reference was made to a machine of this kind in a paper presented by Mr. Timms before members of the British Gear Manufacturers Association last November (ENGINEERING, *page* 789, vol. 178, 1954)*; in it he emphasised the need for improved gear-measuring machines, and stated that the new machine could complete in about half-an-hour a test which would formerly have occupied an operator for four hours. Now an operator was only required for the setting up of the machine, which was capable of a repetitive accuracy per cycle of the order of* 0·000005 *in. The authors wish to acknowledge that the work described in the present paper was carried out in the Mechanisms and Metrology Divison of the Mechanical Engineering Research Laboratory at East Kilbride as part of the research programme of the Mechanical Engineering Research Board. It is published by permission of the Director of the Laboratory.**

WEAKNESSES OF EXISTING METHODS

The extent of the adjacent and cumulative spacing errors of gear wheels and pinions may be determined by inter-comparing the pitches of separate teeth or by direct measurement using some form of indexing mechanism. The former method consists basically in measuring the departures in circular pitch of the adjacent teeth relative to the pitch of one tooth which is selected as a datum. The main weakness of this system of measurement obviously lies in the summation process involved in arriving at the final results, and a high degree of accuracy must be attained for each pitch measurement.

Alternatively, in order to measure directly the spacing of the teeth in relation to their nominal angular position, means must be provided for rotating the gear accurately through angular intervals of 360/T deg., where T is the number of teeth in the gear wheel. Whether this angular indexing has been achieved by means of a circular scale viewed with a microscope, a precision worm and worm wheel, or some other mechanism, it has always presented a tedious and prolonged task for one or more operators, in which a precise angular setting for each tooth of the gear is required. As the pitch angles of most gears are not simple integers, it will be appreciated that successive angular settings have also involved no small amount of pre-calculation or reference to gearing data sheets in order to determine the successive multiples of the pitch angle, for example a 39 tooth gear has a pitch angle of 9 deg. 13 minutes 50·77 seconds.

AUTOMATIC CIRCULAR INDEXING

Each of the above methods of approach is a slow and exacting procedure, involving manual operation of the measuring equipment, which may affect the accuracy of measurement owing to operator fatigue. This is particularly the case when precision gears with more than 100 teeth are measured, as the time for the complete inspection can amount to several hours. The need for some form of automatic circular indexing mechanism, capable of dealing with angular increments of any value, such as that of a 39-tooth gear, has long been recognised at the Mechanical Engineering Research Laboratory, and this paper describes the successful outcome

* *Editor's note.*

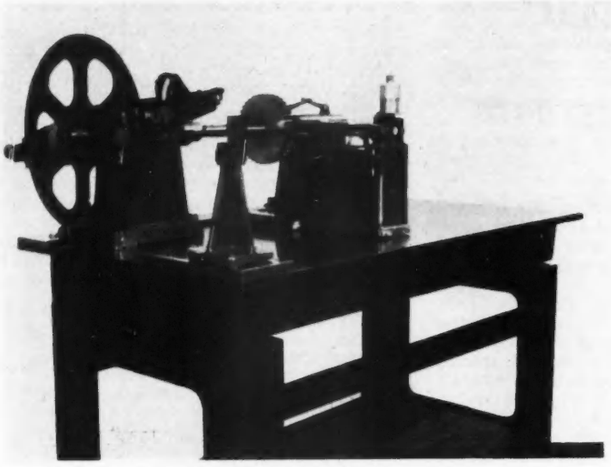


Fig. 1 Hand-operated circular-indexing equipment for measuring adjacent and cumulative gear tooth pitch errors. Based on a surface table, it incorporates a sine-arm, the movement of which is governed by the difference in height between two piles of slip gauges.

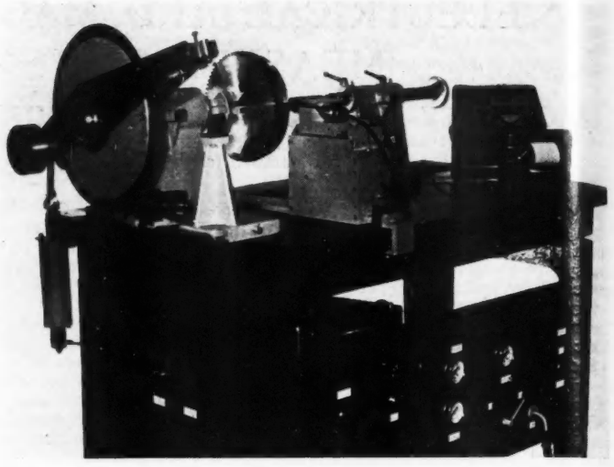


Fig. 2 Fully automatic version of the Tomlinson machine shown in Fig. 1. Developed from the original machine by the addition of pneumatic and electrical equipment, it can complete in about half-an-hour without attention tests which would formerly have occupied an operator for four hours.

of development work carried out in this field at East Kilbride.

The automatic equipment in question has been developed from the manually operated sine-arm type of hob- and gear-measuring machine originated some thirty years ago at the National Physical Laboratory* by the late Dr. G. A. Tomlinson. A description of this machine is given, so that its subsequent conversion to fully automatic action can be appreciated more easily. A photograph of the arrangement and set-up of the equipment on a surface table is illustrated in Fig. 1.

HOB- AND GEAR-MEASURING MACHINE WITH SINE-ARM ACTION

The gear wheel to be tested is mounted on a precision mandrel between centres, and clamped to the live headstock centre, which, in turn, is integral with a large spoked wheel. Mounted freely on the common axis of rotation is a large arm, 14 in. in length to its terminal indicator stylus, which can be locked to the wheel by means of two knurled clamping screws. The wheel can also be locked by means of a third clamp fitted to the surface table itself. As will be seen from Fig. 3, this arrangement forms a simple sine-arm mechanism in which the rotation is effected by movement of the sine-arm, of length L, through an angle θ controlled by the difference in height between the two piles of slip gauges, represented by the expression L sin θ.

The position errors of the tooth flanks relative to the nominal angular rotation θ are measured directly by means of the mechanical indicator shown in Fig. 1 near the gear under test. The indicator consists of a light lever suspended by a flexible steel strip hinge. The short arm terminates in a ball-ended stylus arranged to contact the flank of the gear tooth and a bevelled steel sector is fixed at the end of the long arm.

The measurements are effected by bringing the stylus into contact with the tooth flank and recording the position of the bevelled sector by means of a micrometer attached to the indicator frame. The approach of the micrometer face towards the sector is observed through a reflecting prism against an illuminated background. With this system it is possible to measure accurately an error in tooth pitch of 0·00002 in. The lever arm can be readily retracted from the tooth space before the gear is rotated through the next nominal-pitch movement.

* "Hob and Gear Measuring Machine." National Physical Laboratory Annual Reports, 1922 and 1925; Metrology Department.

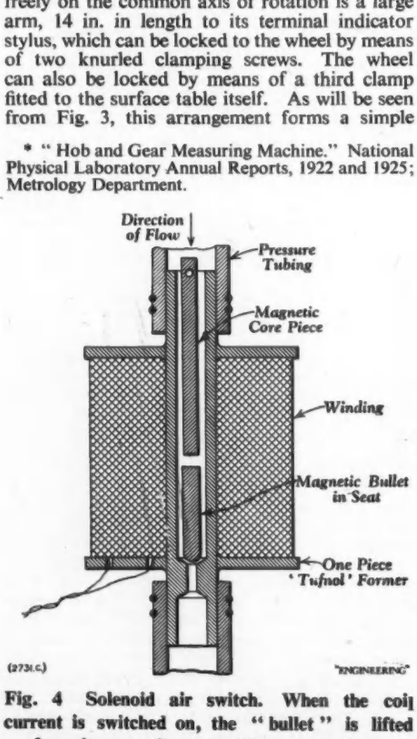


Fig. 4 Solenoid air switch. When the coil current is switched on, the "bullet" is lifted from its seat thus permitting air to flow.

TOMLINSON MACHINE ADAPTED FOR AUTOMATIC OPERATION

It will be appreciated that testing a gear by these means, although

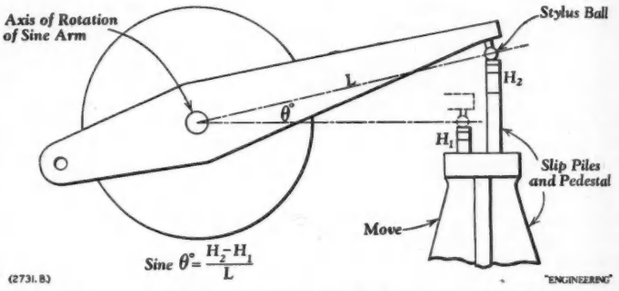


Fig. 3 By movement of the pedestal the sine-arm stylus ball can be brought to bear alternately on each set of slip gauges, thus accurately controlling the indexing of the gear.

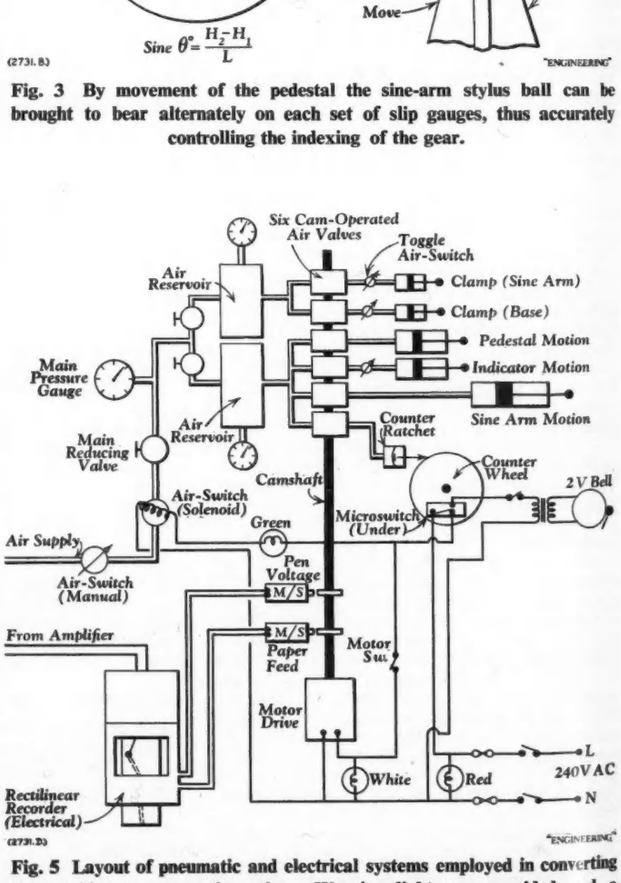


Fig. 5 Layout of pneumatic and electrical systems employed in converting the machine to automatic action. Warning lights are provided and a counting mechanism which operates a cut-out switch when the test is complete.

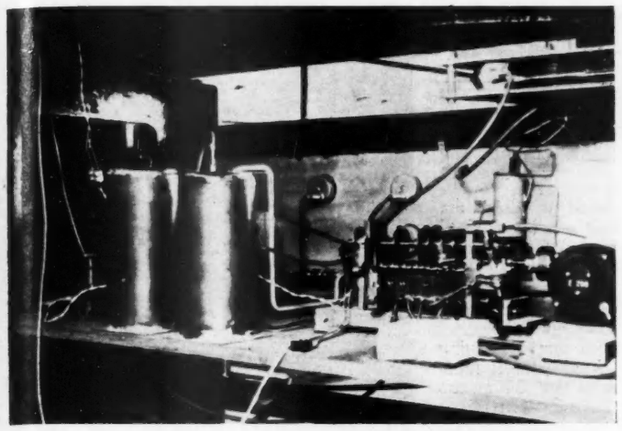


Fig. 6 The controlling mechanism with ancillary equipment is housed behind the front panel of the machine on a shelf built under the surface plate.

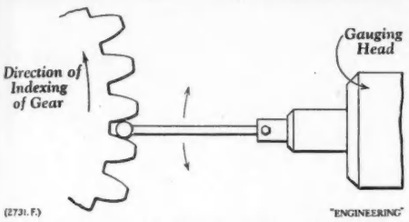


Fig. 7 The gauging head is of side-acting pattern and the stylus meets the gear tooth flank with a contact load of less than 1 oz. Contact occurs on the pitch circle.

accurate, is a long and tedious business, and even when the experimental work is completed, there remains the task of converting a long list of readings into the final form of graphical curves of cumulative and adjacent pitch errors. For each tooth measured, a sequence of some twelve operations is carried out, none of which needs involve human participation. The two slip piles provide all the information the machine requires; repetition only remains. The Tomlinson machine, therefore, provides an excellent basis for the development of a fully automatic gear pitch measuring machine, and such a machine is described in the following paragraphs.

Fig. 2 illustrates the modified machine as it is to-day. It is largely a pneumatically operated mechanism, and can be left to function without the presence of an observer, once the gear has been set up on the machine. At the end of the test, the machine automatically switches itself off, and sounds an alarm to warn the observer that its task is completed. The measurements it carries out are recorded on electrically-marking chart paper in the form of short morse-type dashes. It is then only necessary to join up these marks with a pencil to form the normal cumulative pitch-error curve, with the rectilinear chart-paper ruling forming a convenient graph-paper background.

PNEUMATIC SYSTEM AND ELECTRICAL CIRCUITS

Fig. 5 shows diagrammatically the means employed to convert the machine to automatic operation. The pneumatically powered motion of the various elements is effected by means of small air cylinders. A supply of compressed air is fed to a main pressure regulator via a hand-operated air switch and a solenoid air switch. From the main regulator, the supply divides; one air line is further regulated to a pressure of 30 lb. per square inch, and the other to a pressure of 12 lb. per square inch. From two air tank reservoirs, connections are made to a battery of miniature roller and lever operated three-port air valves, and thence to the separate cylinders controlling the actions of the machine. The air valves are operated by a series of cams mounted on a shaft rotated by a geared-down fractional horse-power electric motor, providing a shaft speed of 3 r.p.m. The air valves and camshaft are built into a compact unit which is driven remotely by the motor through a flexible coupling. Two extra cams on the shaft are used to operate electrical micro-switches, which are in circuit with the chart recorder. The purposes for which these are provided are described later, on page 274.

The electrical circuit is quite straightforward; the red panel lamp indicates when the mains are switched on and the white panel lamp indicates when the motor is switched on. The green lamp serves a double purpose: for indicating that the counter wheel is not at zero, and as a current controller for the solenoid air switch.

SOLENOID AIR SWITCH WITH FILAMENT BOOST

In Fig. 4 is shown a sectional view of this unit the body of which is constructed from Tufnol material. When the electricity supply to the coil is switched off, a steel " bullet," aided by gravity and the air pressure above it, seals the restriction and hence cuts off the flow of air. When the coil current is switched on, however, the bullet is attracted magnetically towards the core-piece at the centre of the electro-magnet, and air can then flow.

As in all devices of this kind, a higher coil current is initially required to lift the bullet against the static air pressure above it, than is subsequently needed to hold it clear of its seating. To provide this variation in current, a tungsten-filament lamp is connected in series with the solenoid. The resistance of such a lamp when cold on first switching on, is considerably less than the normal resistance of the filament when hot. The lamp, therefore, automatically provides the initial solenoid-current boost, and also the subsequent low-current control. By this means, also, the solenoid is prevented from over-heating during prolonged use of the machine. The majority of this ancillary equipment is housed behind the front panel of the machine on a shelf built under the surface plate, and is shown in Fig. 6.

HEADSTOCK AND DOUBLE SINE-ARM

The main spindle is carried on two extra-precision angular-contact ball bearings located at the ends of the headstock casting. The double sine-arm is mounted on the rearward extension of the spindle by means of two deep-groove type extra-precision journal ball bearings having no play between balls and races.

The sine-arm length from the axis of rotation to the stylus ball is about 14 in. A weight is attached to the rear of the arms, sufficient to raise the stylus end of the sine-arm when the air supply to the actuating cylinder has been discontinued. The air cylinder, as shown in Fig. 2, is mounted vertically below the rear end of the sine-arms and is coupled to them by a pivoted connecting link. Air pressure to the cylinder thus causes the sine-arms to descend until contact with the slip pile is made. The stroke speed of the piston is regulated by means of an air bleeder connected to the exhaust end of the cylinder. In addition, the spring cushion shown in Fig. 10 provides a final restraint to the downward movement of the rigid stylus ball, and thus enables a very gentle touch-down to be achieved.

The reason for having two sine-arms coupled rigidly together is a kinematic one. It provides a symmetrical arrangement of the sine-arm assembly relative to the disc and reduces the possibility of slight twisting which has been observed in the single form of sine-arm, due to friction in the main bearing.

AIR-OPERATED CLAMPS AND SLIDING PEDESTAL

There are two air-operated clamps, one of which is mounted between the sine-arms and serves to lock the unit solidly to the wheel. The other, illustrated in Fig. 11, is fixed to the edge of the surface plate in order to grip the wheel and prevent it from turning during periods of free travel of the sine-arms. Air pressure, applied to a piston $1\frac{1}{2}$ in. in diameter, causes the roller mounted transversely on the end of the piston rod to wedge itself between the steel pads, and so grip the wheel against a small insert of brake-lining material. A compression spring fitted to the piston rod serves to release the clamp when the air pressure is switched off.

The effectiveness of these clamps is such that an air pressure of 30 lb. per square inch applied to the piston will render the wheel immovable against all manual efforts to turn it. The two clamps can be isolated from their sequence control by means of the two toggle-operated air-switches to be seen on the end panel of the surface table (Fig. 2). This is necessary when setting up the gear initially.

The side-to-side movement of the pedestal is achieved by means of a small short-stroke air cylinder, shown in Fig. 2. Once again, a spring return is used, and the stroke can be adjusted

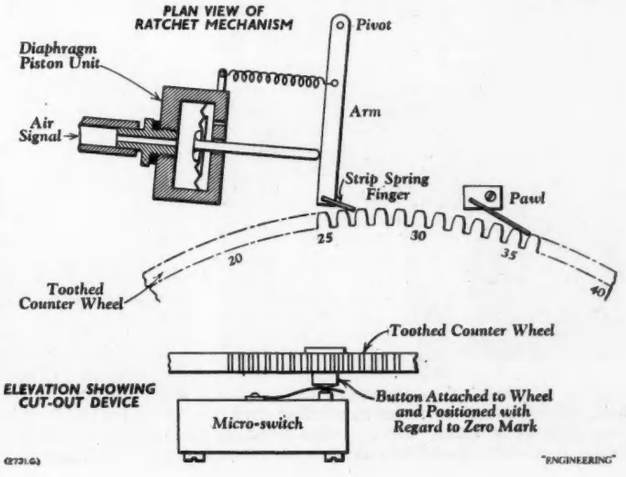


Fig. 8 Details of cut-out mechanism. Counting is performed by means of a toothed wheel which is preset in accordance with the number of test-gear teeth. On completion of the test the machine stops and a warning bell rings.

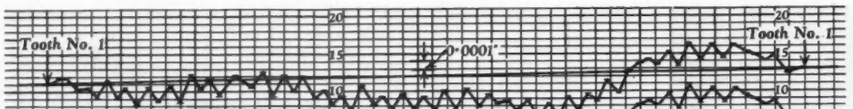


Fig. 9 A typical repeat record of the pitch errors of a 72-tooth gear. Morse-type dashes are made by the machine on electrically-marking chart paper and a graphical result can be obtained simply by joining them. The repetitive accuracy per cycle, which is of the order of 0·000005 in., is indicated by the close similarity of the two records.

for length, and also speed by means of a small air-bleed unit.

PITCH INDICATOR AND RECORDER

At present a Taylor, Taylor and Hobson miniature gauging head and rectilinear recorder are used, as shown in Fig. 2. The head is of the side-acting type with a stylus contact pressure of less than 1 oz. This unit is mounted in a V-cradle and strapped into position by means of a padded cross bar. A small air cylinder contained inside the main base-block powers the movement of the cradle through a pivoted fork-ended lever, and a tension spring provides the return motion. In use, the cradle is gently propelled forwards against a definite but cushioned end-stop, which is pre-adjusted to bring the gauge-head stylus into pitch-line contact with the gear tooth flank (Fig. 7).

As the normal chart-paper feed speed of the recorder is about 12 in. per minute, it was necessary to provide an additional set of cams to switch off the paper feed except for the brief period when the gauge head is in operation. In this way, a morse-dash type of record was achieved, and the recorder thus automatically plotted, in effect, the pitch-error curve points. The magnification of the gauge head, amplifier and recorder can be varied by stages from 100 to 5,000 by simply setting a control knob, so that gears of different grades of accuracy can be examined.

CUT-OUT MECHANISM AND WARNING BELL

The essential details of the cut-out mechanism are shown in Fig. 8 and its main function is to stop the machine on the completion of each test. It consists of a toothed counter wheel which is preset in accordance with the number of teeth in the test gear, and for each measuring cycle the counter wheel advances by one tooth towards its zero mark. When zero position is reached, the micro-switch operates and the motor-drive and solenoid air switches are opened, and a bell rings indicating that the test is complete.

A typical record of a 72-tooth spur gear having a very noticeable adjacent pitch error is illustrated in Fig. 9. The straight line joining the ultimate marks on the record is the datum of the curve, and is obtained by recording the first tooth of the gear at the beginning and end of the test. The slight slope of this datum is due to the fact that the slip pile can only be set to the nearest 0·0001 in., and in nearly all cases a residual of a few hundred-thousandths of an inch per setting occurs, which shows as a slight obliquity of the record. Final provision of the straight-line datum, however, automatically puts this right, and the separate tooth errors can be observed at a glance. The complete record refers, of course, to one set of flanks of the gear; at present it is necessary to carry out a second test to measure the other set of flanks. It is intended, however, to modify the gauge-head unit to measure the upper and lower tooth flanks at each tooth setting, and to provide a chart bearing a double record.

PERFORMANCE AND ACCURACY

An important advantage of the automatic version of the Tomlinson machine is that the human factor is not involved and therefore observational errors, setting errors, and thermal errors due to prolonged handling of the sine-arm, etc., are eliminated. The pneumatic setting of the sine-arm ensures constancy of stylus pressure on the slip piles; thus errors due to varying compression of the ball are also avoided.

The repetitional accuracy of the machine was tested by making a series of measurements on a single tooth of the gear (to do this it was only necessary to arrest the slip-pile pedestal movement) repeated at many positions round the gear, and the repetitive accuracy per cycle was found to be of the order of 0·000005 in. The overall repeatability of results is indicated by the two records shown in Fig. 9.

The present automatic instrument has been developed directly from an existing Tomlinson machine, and the results of this work have provided much experience and the knowledge that accurate gear pitch measurement can be achieved automatically. Consideration is now being given to the most suitable form which a machine designed from first principles might take.

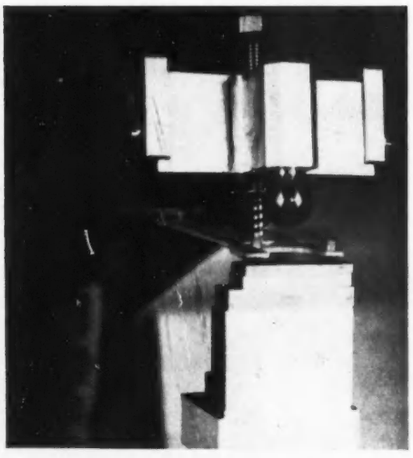


Fig. 10 The double sine-arm incorporates a stylus ball, the downward movement of which is finally restrained by a spring cushion. The resulting gentle touch-down contributes towards accuracy.

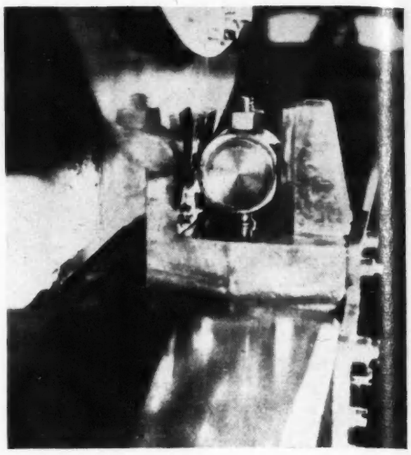


Fig. 11 Air-operated clamp. It is used to prevent the main wheel from turning during periods of free travel of the sine-arm.

FUTURE DESIGN

Primarily, it is considered that the horizontal axes and mandrel should be replaced by a vertical-axis system having a rotating work-table upon which the gear can be mounted concentrically, thus avoiding the need for a large stock of precision mandrels of various diameters, and overcoming any errors due to bending of such mandrels when heavy gears are mounted on the machine. The necessary low-friction support of such a table will probably be achieved by radial- and thrust-type air-bearings. Preliminary experiments in this direction have shown that very precise rotational accuracy can be achieved quite simply by these means, and with very low frictional torque. The sine-arm, mounted beneath the table, would then oscillate in a horizontal plane, and instead of slip-gauge piles, adjustable end-bars would be used, limiting the sine-arm swing in both directions. The pitch- and also concentricity-measuring heads would be mounted on the underside of a rigid but adjustable bridge straddling the circular table, and it is possible that the former head will employ a pair of slit-shaped air jets measuring both flanks of a tooth simultaneously, and providing twin records on a double-pen pneumatic recorder.

EXAMINING MACHINED SURFACES BY INTERFEROMETRY

COMPARISON OF HOBBED AND SHAVED GEAR TEETH

*By J. Dyson**

Before any improvements can be made in metal-cutting machines or processes, it is necessary to be able to measure with some precision the degree and nature of manufacturing inaccuracies. The science of measurement, as applied to mechanical engineering, has advanced steadily through the years enabling successively smaller defects and inaccuracies to be detected. This is particularly true of the interferometer microscope and its ability to measure very small surface irregularities. This instrument has recently been applied to the study of an experimental double-helical pinion, in order to investigate the differences in surface finish produced by hobbing and by shaving.

It should be explained that shaving was developed in the United States about 20 years ago, and was applied originally to motor-car gears as a finishing process. Its use has recently been extended to embrace the largest size of marine gears. The special shaving cutter has its axis "crossed," that is, set at an angle relative to the axis of the gear-wheel under treatment, in a manner similar to that of spiral gears in mesh. The cutter thus makes contact at a point on the tooth flank. As pressure is applied, the contact area spreads, due to distortion of the surface of the gear tooth. The action of the cutter is,

* Of the Associated Electrical Industries Research Laboratory, Aldermaston, Berkshire.

therefore, a combination of cutting and burnishing—hence the characteristic polished surface of the shaved tooth.

Ordinary tests of the surface finish of shaved gears, using the Taylor, Taylor and Hobson Talysurf, did not make the case for shaving, as compared with straight hobbing, overwhelming. However, it is a convenient finishing process, and tests have shown that the involute form can be improved by shaving over that given by poor hobbing. The tests about to be described suggest a warning, however, that although such improvements can in fact be obtained, they are made only at the expense of surface finish. It is not always appreciated that a mat surface may be smoother than a highly polished one.

THE INTERFEROMETRIC METHOD OF EXAMINATION

Interference methods present great advantages for the examination of machined surfaces in view of the ease of measurement, adequate sensitivity and unequivocal nature of the information obtained. However, as normally applied, the sensitivity is actually too high, ordinary engineering errors giving rise to a confused mass of fringes defying interpretation. Furthermore, in many cases, and especially in the case of gear teeth, the surface is almost inaccessible to the usual forms of interferometer.

Both these difficulties can be overcome by making a faithful replica of the surface in a transparent material, and viewing this by transmitted light in an interferometer instead of applying the latter to the metal surface directly. The sensitivity can be lowered by a method due to Zehender* whereby the replica is immersed for examination in a liquid of suitable refractive index μ_L. If the refractive index of the replica material be μ_R, one fringe will represent a difference in height of $\frac{\lambda}{(\mu_R - \mu_L)}$, where λ is the wavelength of the light used. Evidently, the sensitivity can be reduced as much as desired by suitable choice of μ_R and μ_L. In the example to be presented, the replica material was Perspex, and the liquid was water, giving a sensitivity of 0·00013 in. per fringe. This is, of course, a suitable value for accurate engineering purposes.

* Zehender, E., 1952. See Kohaut, A. *Werkstatt u. Betrieb*, vol. 86 (12), pages 725-732, (1953).

The optical system of the interferometer microscope used is illustrated diagrammatically in Fig. 1. It is of the modified Mach-Zehnder type, the number of adjustments being reduced by combining the four reflecting surfaces in pairs in two prism groups. This also has the advantage of eliminating the serious astigmatism which would be present if the conventional Mach-Zehnder system with relatively thick plates at 45 deg. to the axis were employed. The thickness of the prisms is determined by the field which it is desired to cover, and for the experimental model a thickness of $\frac{5}{8}$ in. was chosen. This allows the use of a 25 mm. objective.

The operation of the system is as follows. Light emerges vertically from the condenser and strikes a half-silvered surface at 45 deg. to the axis at the bottom left-hand corner of the diagram. Part is reflected and proceeds horizontally, is then reflected vertically and passes through the replica in its immersion cell. It then strikes a second half-silvered surface in the upper prism, part passing through into the objective, and part being reflected and lost. Part of the beam from the condenser is transmitted by the first half-silvered surface, and is

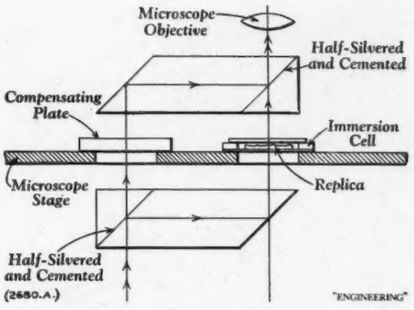


Fig. 1 Optical system of interferometer microscope.

reflected horizontally by the surface of the upper prism; it then strikes the second half-silvered surface, part being reflected vertically into the objective, and part being transmitted and lost. A glass plate is placed in the second beam to compensate for the optical thickness of the replica and its containing cell in order that the two alternative paths should be as symmetrical as possible.

The microscope is focused on the replica and, by suitable adjustment of the prisms, interference fringes may be made to appear in the plane of the replica. These fringes reveal, by distortion of their otherwise straight form, deviations of the surface of the replica from flatness. A suitable light source is a small low-pressure mercury-vapour lamp with a green filter. This gives fringes of good contrast without troublesome adjustments of the interferometer.

The fringe pattern may be interpreted in a simple manner by considering each fringe as a section of the surface in one of a system of parallel, equally-spaced, reference planes. The separation of these planes is given by the expression $\frac{\lambda}{(\mu_R - \mu_L)}$, and is 0·00013 in. in the examples to be shown. The slope of the system of parallel planes is controlled by the adjustments of the interferometer.

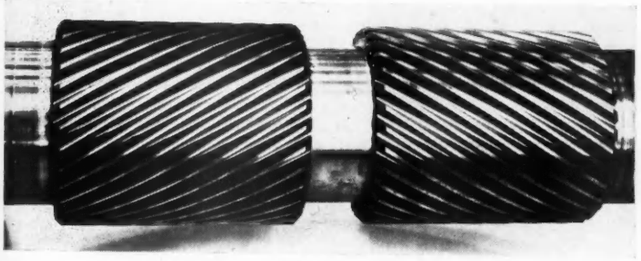


Fig. 2 The experimental double-helical pinion.

Fig. 3 Replica of surface of hobbed gear tooth × 17.

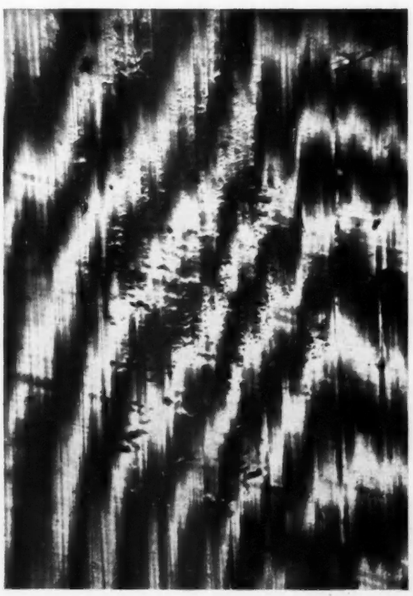


Fig. 4 Replica of dull patch on surface of hobbed gear tooth. × 57.

TEST RESULTS

A photograph of the double pinion referred to in the introduction is reproduced in Fig. 2. The pitch-circle diameter was 5·8768 in., and the circular pitch 0·577 in., the number of teeth being 32. The pinion was hobbed by a protuberance hob on a small 16-in. machine, the indexing wormwheel of which had 64 teeth. This size of hobbing machine is rather smaller than is normally used for high-speed pinion hobbing, but was the only machine available at that time. This fact does not influence the present argument except to prejudice the case for hobbing. One end of the pinion, after hobbing, was "crowd shaved" on a crossed-axis pressure machine, both tooth flanks being shaved simultaneously.

The fringe pattern obtained from a replica of a hobbed tooth is shown in Fig. 3 under a magnification of 17 diameters. The fringes are almost parabolic in general form, due to intersection of the reference planes and the curved involute surface of the tooth. The vertices of the parabolas lie on a straight line which is one of the lines along which contact is made with the mating gear-wheel at any moment. However, the curves are not smooth but consist rather of a succession of short straight portions. This indicates that the surface is not smooth but bears a number of shallow flutes which may perhaps be identified with the lines of deepest cutting of the hob.

The greatest deviation from a smooth curve is somewhat less than the separation of successive fringes, representing an irregularity of the surface of about 0·0001 in. The surface also bears a number of small dull patches which can be seen with the naked eye. The fringe pattern due to one of these is shown in Fig. 4 under higher magnification (57 diameters). The dullness is seen to be due to very small asperities

Fig. 5 Replica of surface of shaved tooth. × 17.

Fig. 6 Replica of scratch-like markings on shaved tooth surface. × 57.

which, as they do not display more than one light-to-dark variation within the area of each one, do not exceed one fringe, or 0·00013 in., in height. This illustration also shows a system of parallel markings running at about 70 deg. to the main machining marks. These are very much less than one fringe in height, and probably do not exceed 0·00001 in. The origin of these marks is uncertain, but they may be chatter marks.

Fig. 5 shows the pattern given by a replica of a tooth finished by shaving. It is at once evident that the general shape of the fringes is much smoother than in Fig. 3, showing that the flutes have been removed giving a very much smoother profile. However, a series of conspicuous scratch-like markings of generally-curved form is shown. Fig 6 shows a small area of these under higher magnification (57 diameters). A large proportion of the surface is seen to be covered with fine grooves which, in a few places, reach depths of several fringes, amounting possibly to 0·0005 in. A system of faint linear markings, similar to those in Fig. 4, may also be seen.

CONCLUSIONS

A new interferometric method of examination applied to the tooth surfaces of an experimental pinion brings out clearly the difference in surface finish obtained by hobbing and shaving respectively. The overall profile of the tooth surface is much improved in smoothness by shaving, but, in this example at least, the fine surface structure is made considerably worse.

It is evident that the interferometric method of examination can be applied to study the results given by a wide range of machining methods.

INGOT-MOULD HOT-TOP

IMPROVED DESIGN FOR KILLED STEELS

A paper entitled "Improved Ingot-Mould Hot-Top Design for Killed Steels" was read by Mr. A. M. Hamilton, of Colvilles, Limited, Glasgow, before the West of Scotland Iron and Steel Institute on Friday, February 18, *and is here reproduced in abridged form. It describes how an increase in yield was obtained from killed-steel ingots with only a slight modification in the design of the hot-tops. It is generally agreed that much higher yields could be, and will be obtained by using more complicated methods, but this simple method is a practical proposition and can be put into operation with the minimum amount of trouble.*

Hot-tops are a necessary evil when making killed steels and, generally speaking, are very inefficient. The poor design is responsible for a tremendous waste of steel, which adds greatly to the cost of the finished material. The hot-top is used to keep the molten metal fluid long enough to fill the cavity which forms when the chill part of the ingot solidifies. This would give a sound ingot at least up to the level of the top of the chill.

Fig. 1 gives a rough idea of how the "pipe" forms in an ordinary hot-top. As the hot-top itself may contain 15 to 20 per cent. of the volume of molten metal in the full ingot, and as this metal is all scrap when the ingot is rolled, it was necessary to discover just how much of this metal was really necessary. It was evident that, provided sufficient insulation could be guaranteed, at least the blacked-in portion of Fig. 2 was unnecessary. It was also evident that the more the metal in the hot-top could be enclosed with insulating material, the longer the metal would remain molten. The ideal hot-top therefore should avoid the unnecessary metal indicated in Fig. 2, and should leave the minimum amount of room (within reason) at the top for casting purposes, and finally have sufficient height to control the depth of the pipe.

Such a hot-top, if covered with a good anti-piping powder, such as blacklead, immediately it was filled, and the powder "puddled" into the top layer of metal, should give a pipe which would start solidifying at the thinnest section of metal, which is at the top, and should solidify as shown in Fig. 3; while solidifying, the further into the ingot that the pipe travelled, the more metal would surround it, so that it should tend to form in the shape of a U until it reached a stage where the whole hot-top would become frozen and the bottom of the pipe should be horizontal. The results of the experiment proved those assumptions to be more or less correct.

It was found to give better results when building a hot-top of this design, so as to give the extra insulation necessary, not to use a steel casting the same shape as the brickwork required, but to use an ordinary hot-top casting and fill in the shape required with extra brickwork. In building a round or square hot-top it can be taken as a rule that the top aperture can be 0·3 of the diameter of the bottom. The height must be increased by one quarter the height of the original ordinary hot-top to give a pipe which will be clear of the chill part of the ingot. With a long narrow hot-top, the long sides should be tapered as above, but the short sides should be built into the same angle of taper.

The experimental work was done entirely on a 10-ton square type of ingot. The taper was adjusted and readjusted until the author was satisfied he had something which would be practical for making almost any type of ingot. The weight in the hot-top was thus reduced to such an extent that, on an average, an extra 5 per cent. yield was obtained from ingots ranging in weight from 10 to 30 tons. The only drawback in using this type of hot-top was that the ingot was not so easily removed from the mould as one with an ordinary square head. This was easily rectified by having a deep set of ingot dogs with a good grip.

A number of graphs showing the weekly or monthly average yield of several types of moulds varying greatly in capacity and covering a period of 18 months have been prepared and their results are summarised in Table I. Some of the graphs showed a lag (as far as increased yields are concerned), but this was due to the time taken to design the hot-tops and equipment.

TABLE I.—*Cogging Rolling-Mill Yields of Inverted Ingots after Introduction of New Type of Feeder-Head*

Ingot size	Average increased yield over Previous Year	
	January to June	July to December
Tons	Per cent.	Per cent.
10	5·3	5·6
15	1·7	1·4
20	3·3	5·8
21	1·2	6·3
30	2·8	5·5

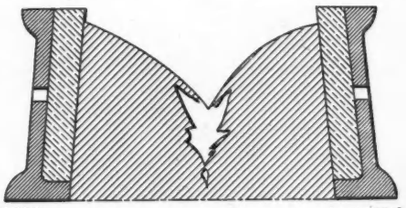


Fig. 1 Pipe formed during solidification of the liquid steel in an ordinary ingot-mould hot-top.

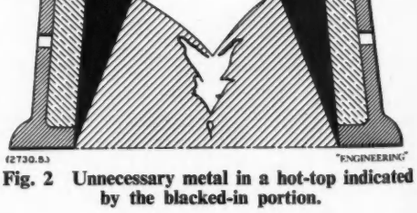


Fig. 2 Unnecessary metal in a hot-top indicated by the blacked-in portion.

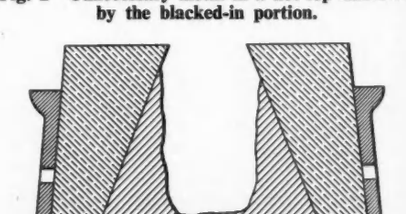


Fig. 3 Improved hot-top adopted, showing U-shaped outline of frozen metal.

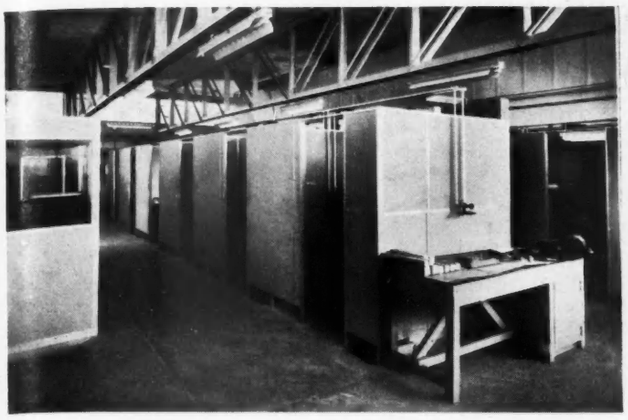


Fig. 1 Booths for examining the properties of welding electrodes in the new research laboratories of Murex Welding Processes, Limited.

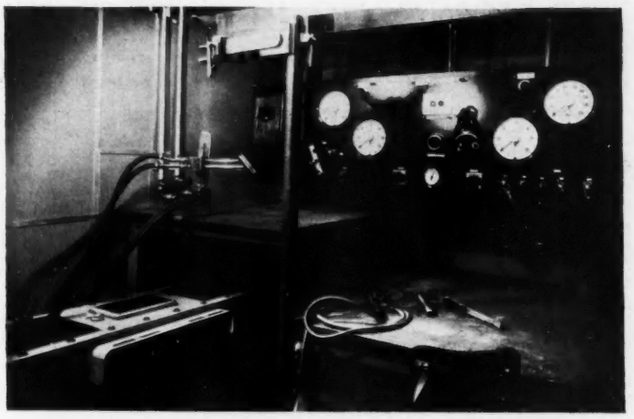


Fig. 2 Interior of one of the booths showing the welding bench and control panel.

WELDING RESEARCH LABORATORIES

INVESTIGATIONS BY MUREX WELDING PROCESSES LTD.

The main purpose of the extensions to their research laboratories, which have recently been opened by Murex Welding Processes, Limited, Waltham Cross, Hertfordshire, is the development of new and improved electrodes to meet the increasing applications of metal arc welding. Incidentally, the basic investigations into raw materials and the control of quality at all stages of production, which are features of the work, reflect the great progress that has been made in these problems.

In all there are 14 separate laboratories, the most important of which are being used for welding research, electrode development, process research, mechanical testing and metallographic and metallurgical investigations. Others are devoted to chemical, gas and spectrographic analysis, X-ray crystallography and the radiographic examination of welded specimens.

ELECTRODE TESTING

The main work of the welding research section is the testing of electrodes which are still in course of development, the evaluation of the suitability of established electrodes for unusual applications, and the quality control testing of factory-made electrodes. The shop is divided into 17 separate booths, which are constructed of fireproof panels framed in extruded aluminium sections and are lined with asbestos, as may be seen in Fig. 1. Each booth is equipped with a control panel on which both alternating and direct-current ammeters and voltmeters are mounted, as well as sockets for electric tools and recorders, push buttons for controlling the supply from a motor-generator set, transformer isolating switches, direct-current regulators, indicator lights, timers and change-over terminals for various open circuit voltages as shown in Fig. 2.

Alternating current is obtained from a transformer and current regulator in each cubicle, while direct current is supplied from one of a number of motor-generators. These machines are housed in a separate room to eliminate noise. Either hot or cold air can be introduced into each cubicle. Other equipment includes furnaces for pre-heating and the heat treatment of welded test pieces. There is also a room in which demonstrations can be given.

AUTOMATIC AND SEMI-AUTOMATIC WELDING

The growing interest in electrodes and materials for use in automatic and semi-automatic welding processes has led to the provision in the department of a laboratory dealing with these matters. This is equipped with welding machines and ancillary plant for the development of electrodes suitable for alternating or direct currents up to 1,500 amperes. Fig. 3 shows a typical machine in this department.

The electrode development laboratory contains pilot equipment for the production of new and experimental electrodes. To provide the necessary material for this purpose, stocks of the standard raw materials used in the factory as well as of unusual minerals and core wires are held in store, and all kinds of flux can be made in appropriate mixing machines. The pastes can then be extruded on to suitable core wires and the resulting flux-coated electrodes fired in ovens under carefully controlled conditions. The ball mills and sieving machinery used in reducing the minerals to a proper degree of fineness for inclusion in the electrode castings are housed in a separate room to minimise noise and dust in the laboratory.

The test house contains equipment for determining the mechanical properties of the metals to be welded and of the welded joints themselves. Its main item is an Avery tensile machine, which is capable of exerting a pull up to 50 tons. Izod and Charpy impact testing machines, a Wöhler fatigue testing machine and a short time creep test unit are also available.

GAS ANALYSIS

The gas analysis section contains apparatus for studying the effects of hydrogen and nitrogen on weld metals, a subject in which great interest has recently been taken. This comprises an evacuated glass tube, containing a sample of steel, which is heated in a furnace so that the dissolved gas is freed. This gas is then pumped out into a measuring system and may also be analysed. Apparatus for studying the solubility effects of hydrogen in steel and for determining the total gas content of a steel by vacuum fusion technique are under construction.

A room which communicates with the metallurgical laboratory is equipped with furnaces for the routine heat treatment of metal specimens. Some of these furnaces are set aside for the quality control of stainless steel specimens to ensure that there is no undue formation of sigma phase in this material at service temperatures of 650 deg. C. Other equipment includes ovens for studying the conditions required for re-drying electrodes when weld metal of the highest quality is required.

Among the apparatus in the X-ray laboratory is a ferrometer for measuring the magnetic properties of a metal sample, and for distinguishing between the magnetic and non-magnetic phases in a steel. It is used for examining stainless steel weld metals to determine the amount of magnetic ferrite in the non-magnetic austenitic matrix, as this can influence the properties of the steel at high temperatures.

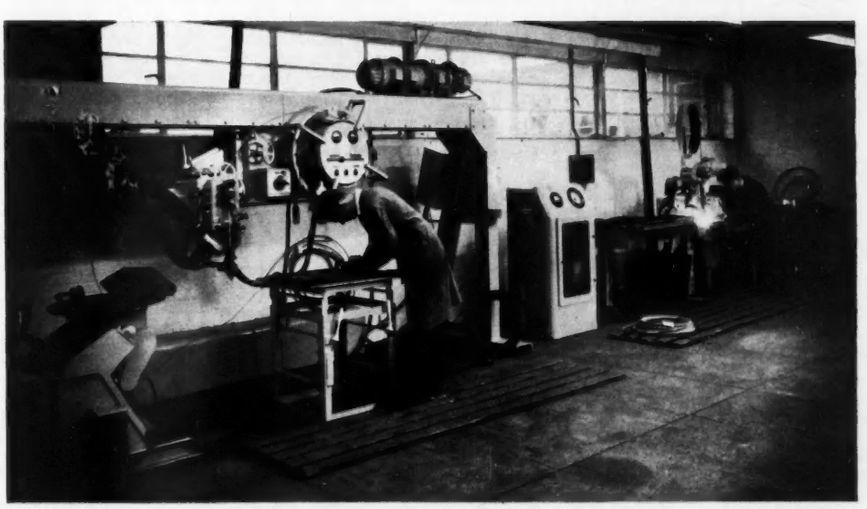


Fig. 3 Machine in laboratory in which automatic and semi-automatic welding is investigated.

RAISING BOILER EFFICIENCY BY BAFFLES AND SOOT BLOWERS

IMPROVED BAFFLE TO REDUCE FLUE-DUST DEPOSIT

Baffles are installed in boiler furnaces for two main reasons: firstly they serve to promote turbulence, thereby increasing the efficiency of heat transfer, and secondly, by controlling the movement of draught-borne dust, maintain the furnace flues in clean condition. In practice, baffles are not always used to best advantage and methods of improving their effectiveness have recently been investigated. As an approach to this problem, Combustion Equipment, Limited, in collaboration with the British Coal Utilisation Research Association, have developed a baffle for installation in Lancashire and economic boilers, which has a number of special features. In addition, some conclusions concerning the location of furnace-tube baffles, and their use in conjunction with flue-dust blowers have been reached.

The improved baffle, which has been developed in the light of experience from an earlier version, consists of a set of specially shaped high-alumina firebricks designed for quick assembly and installation. It has been stated that a baffle has been fitted in as short a period as eleven minutes, and the normal time required—if no alteration to the furnace flues is necessary—does not exceed 45 minutes.

The baffle, which is shown in Fig. 1, is made in such a way that fused fly ash deposited on its surface is retained there, and consequently does not fall in large pieces into the gas passage below the baffle, where it would form an obstruction. Since February 1953, these baffles have been installed in over 200 shell boilers of both patterns, burning coal, coke, oil and wood waste as fuels, and except for pulverised-fuel burners using every form of firing equipment. The result has been an increase in fuel economy, sometimes by as much as 8 per cent., with each of the fuels mentioned.

The economy obtained, however, depends largely on operating conditions and the baffles are moreover limited in application by the stack draught available; nevertheless, it has been estimated that they might profitably be installed in 50 per cent. of all shell boilers in use today including those on ships. Even when boiler efficiency is already high, the advantage of fitting baffles is considerable, and boiler efficiences in excess of 70 per cent. have been improved by as much as 5 per cent.

LOCATION OF BAFFLES

Baffles increase the efficiency of furnaces by promoting turbulence, thereby increasing the rate of combustion and heat transfer, and in the case of solid fuels by keeping furnace flues in clean condition. Formerly, baffles were normally fitted not more than 6 ft. behind the furnace bridge, but experience has indicated that the ideal position at which to install them varies in accordance with the type and size of boiler, the fuel and method of firing and the grate loading. By correct placing of baffles the maximum turbulence and scouring action can be obtained.

These two effects combine to produce a lower gas temperature downstream from the baffles. The amount by which it is lowered depends on operating conditions, but a reduction by 200 deg. to 300 deg. F. in the combustion chambers of economic boilers and 100 deg. to 150 deg. F. in the side flues of Lancashire boilers can generally be achieved. In oil-fired boilers, the installation of baffles is also accompanied by a number of secondary advantages: in addition to the improvements already mentioned, they serve to reduce or even virtually eliminate vibration, and considerably diminish the emission of soot flakes from the chimney.

TURBULENCE AND COMBUSTION RATE

In promoting turbulence, baffles cause more efficient mixing of the furnace gases and consequently give rise to a higher rate of combustion. Gases in the furnace tubes of boilers tend to be stratified, with combustible gases near the crown and air near the bottom, and tests carried out at B.C.U.R.A. reveal the existence of the pattern indicated in Fig. 2.[1] The diagram represents four simultaneous gas samples taken at different positions in the flue of an economic boiler. If the gases near the top are forced downwards by a baffle, they will mix more effectively with those at the bottom, and since they are well above ignition temperature, combustion will take place.

In the absence of any such mixing device, combustion might not occur until the gases change direction in the downtake, which might consequently be subjected to overheating with resultant heat loss. The effect is often quite small, but it can nevertheless cause a side-flue temperature excess of some 50 deg. F., which is equivalent to a loss of efficiency approaching 2 per cent. These considerations apply particularly to economic boilers in which increased turbulence is the main advantage to be gained from the use of baffles; the correspondingly higher rate of combustion in the furnace tube ensures lower gas temperatures in the combustion chamber, smoke box and chimney base, and hence reduced heat wastage.

The part that can be played by baffles in dust dispersal is considerable and the extent of their influence is indicated by Figs. 3 and 4. Fig. 3 shows the furnace tube of a boiler partly filled by dust which has accumulated behind the bridge wall after four-weeks operation; the resulting

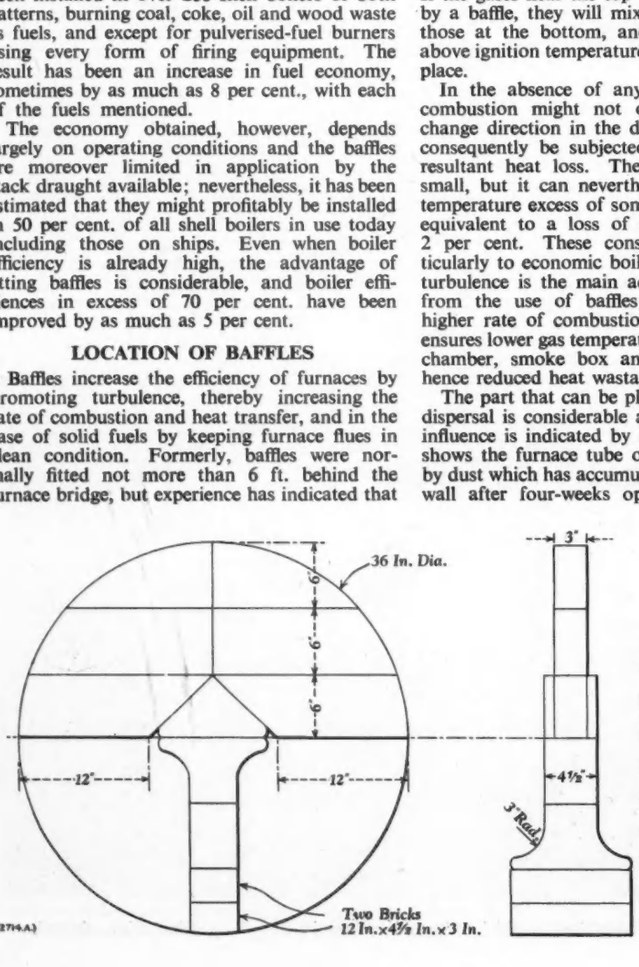


Fig. 1 Furnace-tube baffle designed to retain on its surface any fused fly ash deposited there. In this way, and by controlling the gas flow, the baffle helps to maintain the furnace tube free from dust and ash.

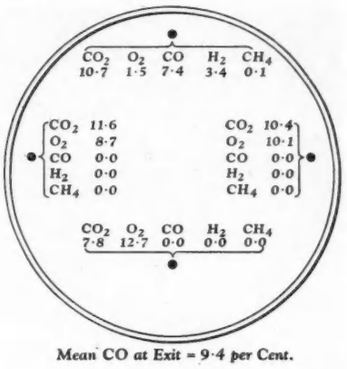


Fig. 2 Gas stratification in the flue of an economic boiler as indicated by four simultaneous gas samples. By creating turbulence, baffles serve to mix the gases thoroughly and so promote rapid combustion.

interference with heat transfer increased fuel consumption by approximately 5 per cent. The photograph reproduced in Fig. 4 was taken through the left-hand aperture below a baffle subsequently installed in the same boiler; it shows conditions after 2,000 hours steaming, and, as can be seen, the furnace tube is almost entirely free of dust.

SCAVENGING ACTION OF BAFFLES

The action of the baffles is to deflect gases which would otherwise travel along the top of the boiler, to the bottom, so that grit normally deposited there is swept away to the flame bed or side flue where it cannot seriously hinder heat transfer. It is important to note that nearly 80 per cent. of the total heat transfer in a Lancashire boiler takes place in the furnace tubes.[2] The extent by which heat transfer can be decreased by dust deposits has been investigated by the Fuel Research Station of the Department of Scientific and Industrial Research, and during six weeks a rise in gas temperature at exit from the side flues of as much as 240 deg. F. has been measured; this is equivalent to a loss of boiler efficiency between 7 and 8 per cent.[3]

Extensive dust deposits occur in boilers when small coals and slacks are used and when the grate loading is high. These conditions are becoming increasingly widespread in industry and it is likely that small coals will form a growing proportion of the total quantity of coal burnt. It follows, therefore, that the coal-fired Lancashire boiler offers the greatest scope for the future application of baffles.

BAFFLE-BLOWER COMBINATION

The installation of baffles in boilers of this kind has in some cases, however, revealed certain difficulties, which have in turn led to a number of interesting developments, and in particular to the conclusion that the future of baffles will be associated with the use of soot or flue-dust blowers. The operating difficulties encountered were concerned with the behaviour of the flue-dust deposits on the baffle itself, and in the space immediately between the bridge and the baffle.

During the investigation of this problem, baffles were fitted in two 30-ft. by 9-ft. Lancashire boilers equipped with chain-grate stokers burning a small fuel, and each generating some 12,000 lb. of steam per hour. Very severe draught loss occurred after approximately ten days steaming. Subsequently, the fires were drawn and the baffles inspected.

It was found that deposits of ash on the baffle itself had fused, and flowed down into the gas passage below, considerably reducing its area; there was on the other hand only a small amount of dust immediately behind the bridge. The configuration of the fused ash and dust is indicated in Fig. 5, which represents end and side elevations of the choked baffle.

It was inferred that the flue dust carried in the

Fig. 3

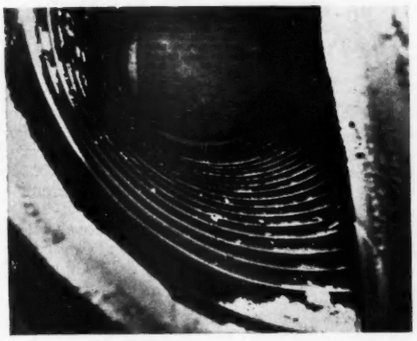


Fig. 4

Fig. 3 shows the furnace tube of a boiler partly filled by dust which has accumulated behind the bridge wall during a few weeks operation; the interference with heat transfer increased fuel consumption by 5 per cent. Fig. 4 shows the boiler after 2,000 hours steaming with a baffle installed.

gases had impinged on the baffle and adhered to it; the dust had thus been subjected to continuous high temperatures, and consequently had on melting run down into the gas passage, so causing the blockage.

Consequently it was suggested that if the baffle were moved further from the bridge these conditions would be less likely to develop. From Fig. 6, which shows a section through a furnace tube, it is apparent that less dust will impinge on a baffle at point B than at point A, and moreover the gas temperature will be lower at point B than at point A, thus further reducing the tendency for ash to fuse at the baffle. Accordingly the baffles were reinstalled about 10 ft. from the bridge.

STEAM JETS IN FURNACE BRIDGE

Although no further trouble was experienced with the baffle in the new position, its value was reduced to some extent since a shorter length of the furnace tube was kept clean, and since the effect of the baffle in promoting turbulence was introduced later in the progress of the gases along the furnace tube. To compensate for these disadvantages, it was proposed that steam jets be installed to operate through the bridge wall; these would blow the grit that fell in front of them as far as the baffle, where the gas flow could take over, and sweep it out of the furnace tube.

Another boiler, also fitted with a chain grate, was selected for testing the baffle-blower combination, and a specially designed blower unit was fitted in each bridge. These were operated once daily for three weeks, after which the furnace flues were examined. It was found that the flue dust had been blown about 10 ft. forward from the bridge, and from that point a deposit extended to the downtake. The furnace tube was cleaned and the baffles were then installed 10 ft. from the bridge. This boiler has now been steaming well over six months without appreciable deposits collecting in the furnace tube.

The difficulties associated with ash fusion can also take the form indicated by Fig. 7. From this illustration it is evident that a large quantity of flue dust has accumulated between the bridge and the baffle, and that it has partially blocked the gas passage. This occurrence is rather more frequent than that previously discussed, and the major causes in order of importance appear to be: high loading, a high percentage of flue-dust carry over, and an ash fusion temperature lower than normal.

DUST DEPOSIT WITH FUSED CRUST

In every case of this kind, the deposit behind the bridge was found to include a fused upper layer, as depicted in Fig. 8, and beneath it previously deposited layers which still remained as dust. A possible explanation of the fused upper layer is the poor conductivity of those below, which consequently prevent the escape of heat from the top deposits; these are thus raised to fusion temperature and melt to form a crust of slag. Had a bridge blower been installed, therefore, the initial deposits would have been swept away before much dust could accumulate, and the difficulty described would not have arisen.

To test this conclusion, baffles were refitted and bridge blowers installed in four Lancashire boilers in which the fault had proved particularly serious; as a result efficient working was restored. The combination of baffle and blower has been found to provide a satisfactory solution to the problem even when the fuel burned is of the poorest quality.

Not only do baffles and bridge blowers maintain the furnace tube in a clean condition, but baffles serve in addition to increase the rate of combustion; consequently it is reasonable to suppose that the combination would contribute more to efficiency than the conventional soot-blower system, which is employed for its cleaning action alone. To obtain evidence of this, a pair of baffles was installed in a chain-grate fired Lancashire boiler in which a complete system of flue-dust blowers had been in operation for some time. The result was a reduction in side-flue temperature of 100 deg. F. and an improvement in overall thermal efficiency of 4 per cent.

The installation of bridge blowers should be performed with care, otherwise excessive maintenance may later be necessary, and it is important moreover that they be made of a suitable heat-resisting material such as Nimonic alloy in order to withstand the high temperatures encountered in the ash pit. The baffles, which comprise eleven standard interlocking units, including base, column and centre piece, are made by Thomas Marshall and Company, Limited, Locksley, Sheffield, The baffles are put together in their final position in the boiler.

From the investigations carried out, it can be concluded that baffles may profitably be used wherever spare draught is available, and that the combination of baffles and bridge blowers is an effective means of preventing the accumulation of flue-dust deposits; at the same time they serve to promote gas turbulence thereby stimulating combustion. The result of both these effects is to give increased boiler efficiency.

The tests performed have shown that by confining flue-dust blowers to a small area and changing the direction of the gas stream in the furnace tube, dust deposits no longer occur in that area; the same principles, applied in the bottom and side flues, might have a similar result. This line of development is being pursued.

The information contained in this article has been supplied by Mr. A. E. Mordin, A.Inst.F., joint managing director of Combustion Equipment Ltd, 61 Belsize-lane, London, N.W.3.

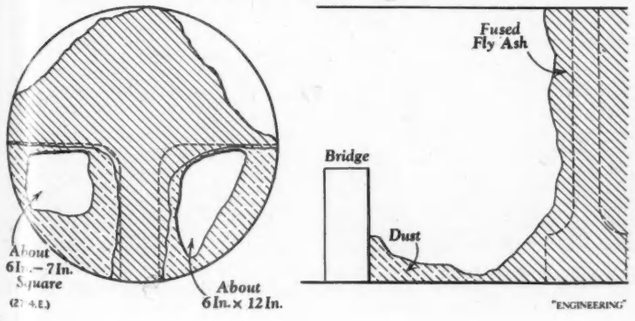


Fig. 5 In certain cases it has been found that flue dust carried in the gases impinges on the baffle and adheres to it; the continuous high temperature causes it to melt and run down, thus partly closing the baffle apertures and constricting the gas passage. The remedy is given in Fig. 6.

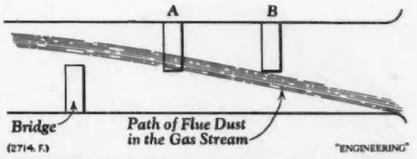


Fig. 6 If the baffle is transferred from A to B less ash will fall on its surface (see Fig. 5).

Fig. 7 Deposit of fused ash and flue dust between furnace bridge and baffle. This form of deposit, which occurs frequently and is shown diagrammatically in Fig. 8, obstructs the furnace tube.

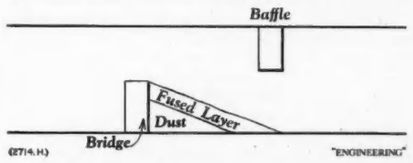


Fig. 8 The deposit illustrated in Fig. 7 consists of a fused surface layer beneath which are previously accumulated layers of flue dust. Its formation can be prevented by means of steam jets installed in the bridge.

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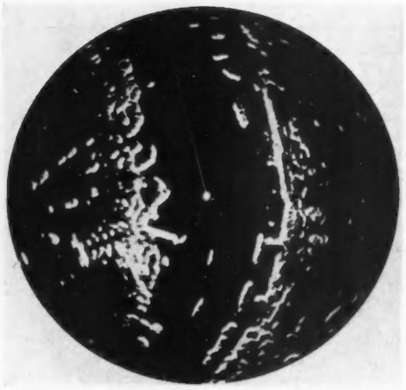
[3] Fuel Research Station, D.S.I.R. Technical Paper, number 55 (appendix III), H.M. Stationery Office.



Taken on the ½-mile range, this display of the Thames shows the definition obtainable on the screen of the Decca "212" radar set. The ships President, Chrysanthemum and Wellington are shown at their moorings.

RADAR FOR SMALL SHIPS

High Performance Set for Constricted Waters

Under present day conditions, small vessels have as much need for radar navigation aids as larger ones. To meet the demand that is arising in this field, Decca Radar, Limited, Brixton-road, London, S.W.9, have introduced a low-cost set which retains a very high performance, especially on short ranges. This new set is known as the 212, and is the fourth set that the company has introduced during the past five years to meet the needs of different classes of vessels. The 212 has a maximum range of 30 miles, descending in six steps to half a mile. It is suitable for vessels down to about 100 tons.

As long wave-guide runs are not expected in most of the craft for which this set has been designed, the radar frequency unit is separate from the scanner and its motor. This reduces the weight of the complete scanning unit to 78 lb. The angle of the reflector is such that snow will not collect on the working surface. The horizontal beam is 1·75 deg. at half-power points, and the vertical beam is 20 deg. The R.F. unit has an output of 10 kW and uses a 0·1 micro-second pulse for the shorter ranges and one of 0·2 micro-second for the longer, the change being made automatically by the range switches on the display unit. The latter has a 9-in. tube and can be mounted either on the bulkhead, on a table or on a pedestal. It weighs 59 lb. The ranges available are: 30, 15, 8, 3, 1 or ½ mile—an example of the latter (taken in the River Thames) is shown in the illustration. The fourth unit, that completes the equipment apart from the main control switch is a voltage-regulated rotary converter, weighing 137 lb., able to supply the set from the ship's mains.

As will be seen from the illustration, picture clarity is good. The minimum distance for discrimination on the ½-mile range is 25 yards or less, enabling navigation to proceed in the constricted waters normally visited by smaller craft. The display unit is splash proof and can be fitted with Deccaplot navigation equipment. A position on the main control switch allows the aerial to be kept turning without the remainder of the equipment operating, to prevent the formation of ice on the moving parts. Although primarily designed for small craft, the use of this set is by no means confined to them, and a waterproof casing is available so that the R.F. unit can be mounted below the scanner, and the need for a long wave guide removed, if the set is installed in larger vessels. It has been suggested that the set would make a useful short-range addition to some older installations. The whole equipment has been designed to meet the requirements of the Marine Radar specification issued by the Ministry of Transport.

36-MVA ALTERNATOR

Two overhung Pelt on Wheels

The first of two 36-MVA 11-kV alternators has recently been placed in operation in the Artias power station of Sociedad Productora de Fuerzas Motrice S.A. in Spain; and it is expected that a second similar machine will have been commissioned during February.

Both these machines have been constructed by the British Thomson-Houston Company, Limited, Rugby, and each is driven by two single-jet Pelton turbines, which were manufactured by Etablissments Neyrpic of Grenoble and operate under a head of 2,600 ft. As will be seen from the accompanying illustration, one wheel is overhung from each end of the generator shaft.

The water wheel alternator being erected.

The station is situated close to the Franco-Spanish border at a height of 3,700 ft. above sea level so that transport was difficult. The alternator rotor therefore consists of a pre-stressed hollow forging weighing nearly 40 tons to which stub shafts are bolted. The ten poles are carried on this forging by four dovetails so that the rotor could be dismantled for shipment.

* * *

COLLIERY ACCIDENTS

Report of the Chief Inspector of Mines

The report of H.M. Chief Inspector of Mines for the year 1951 was published in September, 1952; that for the year 1952* has appeared only in January, 1955. It is explained that the delay has been due to the work imposed on the "depleted and already overburdened staff" in connection with the preparation of the draft of the new Mines and Quarries Bill. This matter is of wider interest and importance than lies in the fact that colliery managements have had to wait a few months longer than usual for the latest report. Many, many times throughout the report colliery accidents are attributed to inadequate maintenance and supervision and although it is not the business of the inspectors to carry out these activities, their presence and advice can have important influence on those responsible. The position is that while at the end of 1952, there were 143 inspectors, there were 33 vacancies; this is a formidable percentage. Anxiety is particularly expressed about the supply of senior inspectors, the average age of those now serving exceeding 50 years.

The accident record for the year 1952 was improved in the sense that the number of persons killed was only 420 as compared with 487 in 1951 and an average of 583 for the previous ten years; it was, however, unsatisfactory from the point of view of the fact that the number of persons "reportably injured" rose from 1,942 in 1951 to 2,109 in 1952. However, a "reportably injured" means seriously injured, and as it is no more than a matter of chance whether or not a serious injury results in death, it is not satisfactory that the combined total of those killed and seriously injured rose from 2,429 in 1951 to 2,529 in 1952. The true measure of the growing improvement in mining conditions is provided by the facts that in the last decade fatal accidents have decreased by 52 per cent. and non-fatal accidents by 25 per cent.

Falls of ground continue to be the cause of the greatest numbers of fatal and serious injuries, followed by haulage accidents. Explosions and fires, which are responsible for the more spectacular events, and which attract the most public attention, are not, over the years, the major cause of accidents. A single event may result in a high figure for some particular year but even in 1951, when the deaths from explosions and fires reached a total of 100, the figure was only half that of the deaths due to falls of ground in the same year. Deaths due to explosions and fires in 1952 amounted only to the small total of 8. The other two classes under which colliery accidents are recorded—shaft accidents and surface accidents—have both shown remarkable uniformity over a number of years, the number of deaths from shaft accidents being in the neighbourhood of 20 and from surface accidents round about 50. The totals for 1952 were, respectively, 23 and 44.

Falls of ground, the major cause of accidents, are difficult to deal with, as their control lies almost entirely in the hands of individual workmen, some of whom are careless and some of whom take unwarranted risks. The report devotes many pages to a review of the whole subject. As already mentioned, the inspectors cannot control the activities of the workpeople but they may influence them by advice. As an example, in connection with falls at roadheads, it is pointed out that "some rippers do not yet realise" that supports "are provided primarily for their own protection and are not intended to be set towards the close of the ripping shift to protect passers-by." The more inspectors there are in service, the more opportunity there will be for individual advice on matters of this kind. Some reference is made to roof bolting as a method of controlling falls, but there is no indication that it was in use in the year with which the report deals.

The prevention of fires on conveyors is a matter of design and maintenance rather than one concerning the activities of the miners themselves. Some particulars of four cases are given in the report. In one, a fire discovered on a Sunday morning, had originated at the return drum of a gate belt conveyor. The guide plate had a jagged hole worn by the belt running out of centre. Strips had been cut from the edge of the belt and these had been tightly coiled on the boss and shaft of the drum. The friction heat generated had ignited coal dust which had smouldered and finally burst into flame. In connection with this matter, some experimental work carried out by the Safety in Mines Research Establishment is referred to. Smouldering was

* Report of H.M. Chief Inspector of Mines for the year 1952. H.M. Stationery Office (3*s.* net).

started in coal dust on the floor of an underground roadway; it was arranged for observers to pass the spot at intervals and it was found that in surprisingly few cases could the observer say whether smouldering was in progress or not.

In connection with the use of compressed air, a long detailed section of the report describes a number of compressed-air explosions and fires. There were six of a serious nature in 1952. They cannot all be dealt with here, but as an example, at a large colliery in the North Eastern Division the explosion of a 14-in. compressed-air pipe range did so much damage that winding at the shaft concerned was stopped for nine months. Investigation after the disaster revealed large deposits of carbonaceous material in the discharge pipe from reciprocating air compressors and a 16-in. main contained 33 lb. of this material. The air received contained semi-solid carbonaceous matter and emulsified oil and 48 hours after the explosion smouldering coke was found at the inlet to a T-piece at the end of the receiver. Not only the lay-out of the piping but the filtering arrangements was severely criticised. This and the other incidents dealt with lead to unfavourable comments on matters of design, construction, installation, operation and maintenance.

LIGHTING A STEELWORKS

INDOOR AND OUTDOOR METHODS AT LACKENBY

The lighting of large, high buildings always presents difficulties, as also does that of approach roads and railway yards. At the Lackenby works of Dorman, Long and Company, Limited, the problem has been met by using a combination of mercury and tungsten lights, supplied by both the British Thomson-Houston Company, Limited, Rugby, and the General Electric Company, Limited, Kingsway, London, W.C.2.

A general description of the plant was given in ENGINEERING, vol. 178, page 180 (1954); briefly it consists of a main building, 1,083 ft. long by 230 ft. wide divided into three longitudinal bays—the stock bay, the charging bay and the casting bay—together with offices and ancillary buildings, approach roads and a large area of railway sidings. During construction, 1,000-watt B.T.H. tungsten flood lights were used, supplemented by smaller lights on the cranes.

While the main access road to the site was under construction in January, 1951, twelve concrete columns with 27-in. long brackets were erected at a spacing of 300 ft. as an initial single-sided lighting arrangement. These columns were fitted with horizontal enclosed lanterns housing 250-watt high-pressure mercury lamps. It was intended that at a later date a further set of columns would be erected on the other side of the road, giving a staggered layout of 150 ft. spacing. During the dark nights, however, it was found that by increasing the lamp size from 250 watts to 400 watts the initial twelve lights were adequate. This lighting is controlled by a Venner time switch.

Each railway siding on the Lackenby site covers an area of 1,200 to 1,800 ft. long by 300 to 500 ft. wide. It was decided that no posts, which could cause obstruction and which would be liable to damage, should be erected on the sidings. It therefore followed that light sources must have long throws and high power so that a minimum number of points could be used, and this in turn required that the sources must be as high as possible to reduce glare. Thus six 150-ft. lighting towers were erected, each capable of accommodating 48 1,000-watt floodlight fittings. The fittings used were the B.T.H. floodlights used since the beginning of the site work and which had proved suitable for this application.

The spacing between towers varies between 1,100 ft. and 1,400 ft., and sites were selected so as to interfere as little as possible with the railway layout and yet allow the maximum number of floodlights possible to be brought to bear on areas requiring lighting. Spacing to mounting height ratios are not more than 10 : 1. The illumination planned was 0·25 lumen per square foot at track level with up to 1·5 lumens per square foot around the groups of railway switches at the end of the sidings. Readings have confirmed that the level of illumination is within close limits of the value planned. In average weather conditions it is claimed to be possible to read a pencil-written address label on the side of a truck even when the truck is 500 ft. from the nearest tower base. An idea of the illumination obtained can be gathered from Fig. 1.

The casting and charging bays are each illuminated by 50 G.E.C. circular high bay reflectors housing alternately 1-kW Osram mercury lamps and 1·5-kW tungsten lamps. The fittings are mounted in a single row at a height of 95 ft. in the casting bay, and 73 ft. in the charging bay, giving an average illumination of 6 lumens per square foot with almost complete absence of shadow. The combination of mercury and tungsten lamps gives a very agreeable warm light while still retaining a high lumen per watt ratio. Fig. 2, which shows the lighting of the casting bay, should be compared to Fig. 7 of the earlier article, which shows the same bay under natural lighting conditions.

Fig. 1 The railway sidings are lit by six 150-ft. towers, each carrying 48 1,000-watt fittings and giving an average ground illumination of 0·25 lumen per square foot.

Fig. 2 Alternate mercury and tungsten lamps, of 1 kW and 1·5 kW respectively, light the casting bay from a height of 95 ft.

In the stock bay the same method and type of illumination has been used except that the fittings are arranged in two rows of 17 fittings—one row of mercury and the other of tungsten units.

The fittings used consist of an anodised aluminium reflector with a vitreous enamel canopy and an annular ventilation opening which also allows some upward illumination. This vent provides convection air-flow over the reflector surface, thus retarding the deposition of dirt. The fittings are on counterbalanced arms, pivoted to the side of catwalks in the roof so that the whole unit may be easily inverted for cleaning and lamp replacement.

The stripper building, which is at the south end of the plant, is 280 ft. long, 90 ft. wide, and 58 ft. high, with a crane gantry extending nearly 250 ft. beyond the main building. The interior is illuminated by two rows of eight G.E.C. fittings, housing alternately mercury and tungsten lamps. As in the other bays, these fittings are attached to the catwalks. The lighting for the area outside the stripper building is provided by nine G.E.C. area floodlights each housing 1-kW Osram mercury lamps and mounted between 50 and 60 ft. above ground level.

Amongst the first buildings to be completed were the maintenance shops which are illuminated by over 100 Blended Light fittings supplied by B.T.H., each housing a 400-watt mercury discharge lamp and a 750-watt filament lamp.

In the main office block, the offices are separated by moveable metal partitions which can be positioned at pre-determined points, making offices of unit size, the minimum size being 13 ft. by 17 ft. The number and size of the offices can thus be altered by removing or repositioning the partitions. Lighting for a unit-size office was determined at 14 lumens per square foot using three 5-ft. 80-watt reflector fittings, suspended at 9 ft. 6 in. above the floor.

All fittings are fed from three-pin 5-ampere outlet sockets recessed in the ceiling, which is of " Bison " pre-cast beam construction. These points are carefully laid out so that wherever a fitting is moved, it can be wired to a socket with the minimum amount of trailing lead. An illumination of 14 lumens per square foot has been obtained. Nearly 200 Mazda vitreous enamelled, slotted reflectors have been wired in this manner, each fitting being of the " Instant Start " type. In the single-storey canteen varying sizes of B.T.H. " Spheriod " opal spheres and " Harcrescent " opal ceiling fittings were installed.

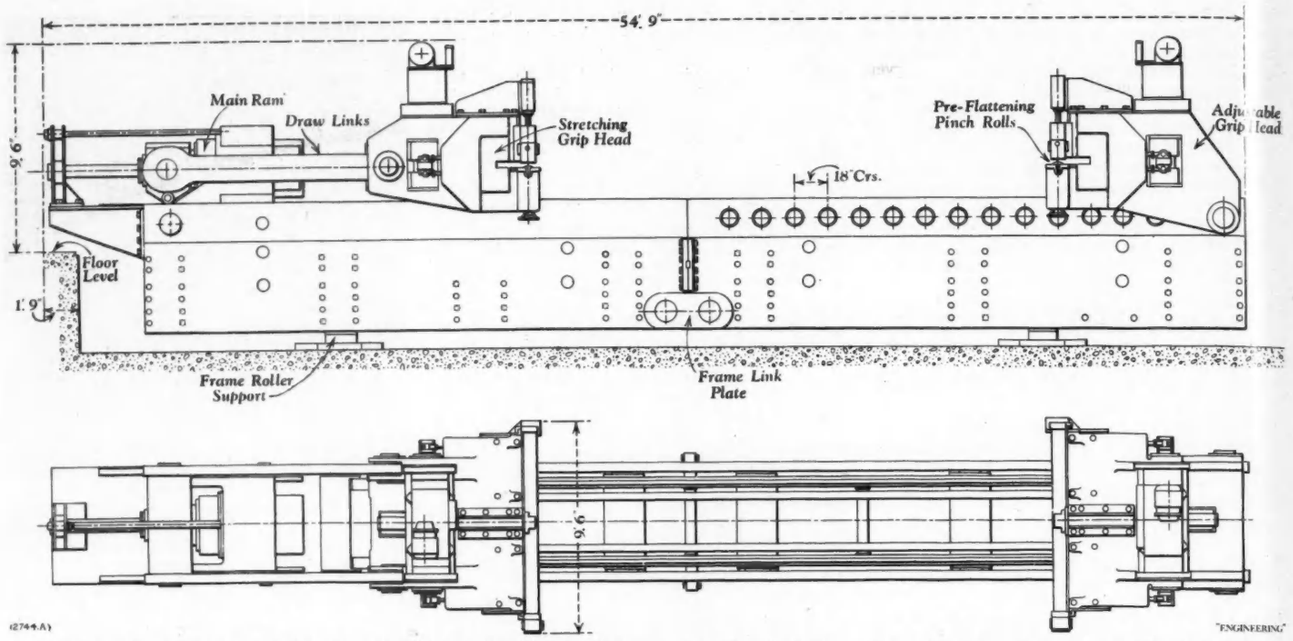


Fig. 1 General arrangement of the Bigwood 800-ton stretching machine. It has been built for a Norwegian light-alloy works. When it is installed there, the main frames will be set in foundations below floor level so that the working parts are at a convenient height.

STRETCH-FLATTENING OF LARGE SHEETS AND PLATES

HYDRAULIC MACHINE WITH 800-TON PULL

Stretch-flattening of wide flat-rolled products is practised extensively in both the ferrous and non-ferrous industries, and the process is so well known that it requires very little introduction. Stretching sheets beyond the elastic limit produces a higher degree of flatness than can be obtained by roller-levelling, eliminates residual stresses, and ensures that the sheet is free from scratches and other markings. In the case of annealed low-carbon steels it temporarily suppresses yield-point elongation, and so avoids the risk of stretcher-strains appearing if the material is subsequently used for pressed or drawn products. Stretching machines, consisting of a pair of grips to hold the sheet and means of applying a controlled load hydraulically, have long been made. In recent years developments in the sheet-using industries, notably in aircraft manufacture, and other factors have brought about a demand for larger and heavier sheets and plates, and this in turn has created the need for stretching machines of greater capacity.

The machine illustrated here has been designed and built by Joshua Bigwood and Son, Limited, Wolverhampton, for a Norwegian light-alloy works, and is claimed to be the largest so far made in Europe. It has a maximum stretching pull of 800 tons (1,792,000 lb.) and will accommodate sheets up to 90¼ in. (2,300 mm.) wide. The maximum and minimum sheet lengths which the machine will accept are 315 in. (8,000 mm.) and 59 in. (1,500 mm.) respectively. The grip jaws have a range from zero to 1¾ in. (44 mm.) and the stroke of the stretching ram is 36 in. (914 mm.). The stretching speed is infinitely variable from zero to 0·39 in. (10 mm.) per second, and the take-up speed, when there is no load, is 3·5 in. (90 mm.) per second. On the return stroke the ram travels at 1·34 in. (34 mm.) per second.

The machine is equipped with hydraulically-operated grip jaws, one pair of which is adjustable along the frame to accommodate different lengths of sheet, as shown at the right-hand end of Fig. 1. To enable sheets which may be badly buckled to pass into the grip jaws, hydraulically-operated pre-flattening rolls are provided, as shown in Fig. 4. The hydraulic gear, which was made by Towler Brothers (Patents), Limited, Rodley, Leeds, is divided into three units. A motor-driven unit mounted independently of the machine adjacent to the main stretching cylinder and ram provides the stretching load and also advances the ram for "take-up" and returns it after stretching. Mounted on the top of the stretching grip head is a second motor-driven pump for operating the grip jaws and pre-flattening rolls, while a third unit, mounted on the adjustable grip head, operates the jaws and pre-flattening rolls on that part of the machine, and also provides the hydraulic pressure which actuates the anchor pins to lock the head to the frame while stretching is in progress. All the controls are grouped on a desk adjacent to the stretching grip head.

The machine is carried on a heavy fabricated frame made from solid steel plates, each side member divided into sections for ease of transport and erection. The frames are bolted together at the flanges, and are spaced and secured by heavy cross bridges at intervals along their length. Heavy link-plates are fitted on the tension side of the neutral axis at the points where the side members are joined at the centre (Fig. 1). The frame takes the load stresses, and will be erected on site in a simple foundation pit with rollers to enable it to deflect without

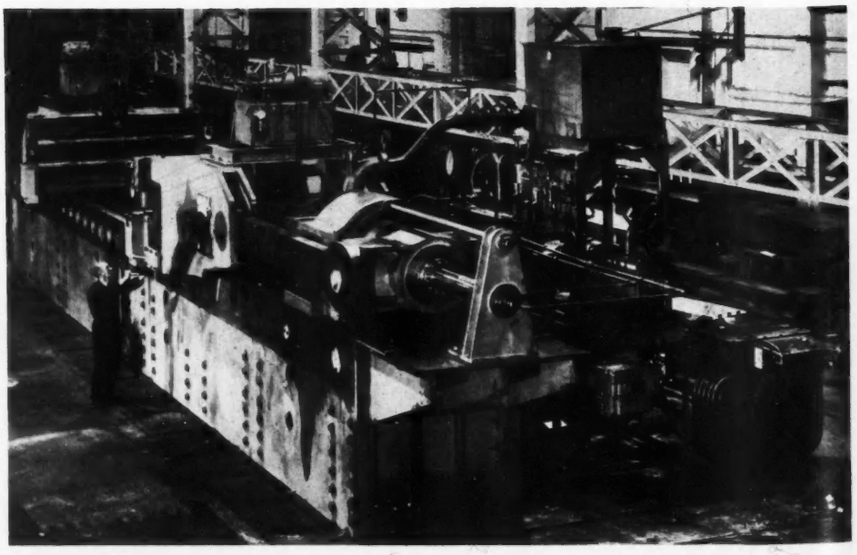


Fig. 2 The machine stretches plates and sheets beyond the elastic limit to obtain a high degree of flatness and to eliminate residual stresses and surface marks. The plate is held at one end by an adjustable grip head (on the extreme left) and then held and stretched by the other grip head which is pulled by a hydraulic cylinder.

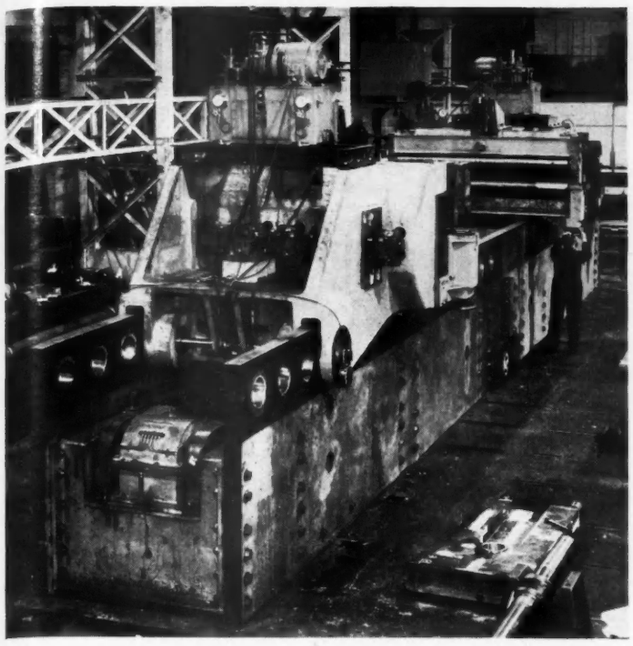


Fig. 3 The adjustable grip head can be fixed at any position along the bed at intervals of 18 in., using hydraulically-operated pins to hold it. By this means plates between 4 ft. 11 in. and 26 ft. 3 in. in length can be accommodated.

restraint under load. The depth of the foundations will be such that only the top part of the frame will be above ground level, and the grip heads will thus be brought to a convenient working position.

ADJUSTABLE GRIP HEAD

The adjustable grip head is mounted on a travelling carriage running on rollers on a pair of flat-bottomed rails carried on joists fixed to the bed between the side frames (Figs. 3 and 4). This head can be traversed along the bed as required to suit sheets of various lengths, and can be locked in position by anchor pins which engage in holes in the side frames. These holes, spaced at 18-in. centres, are lined with replaceable hard-chromium plated steel bushes, and the anchor pins, when they are engaged, pass right through the holes and into the outside of the carriage; they are thus in double shear. As the holes are at 18-in. centres and the stretching ram has a stroke of 36 in., sheets of any length between the maximum and minimum limits can be handled by locking the grip head in the appropriate anchor holes.

The adjustable head is moved along the bed by draw chains passing over sprockets driven by an electric motor and worm-reduction gear noused between the frames. Tension adjustment is provided by adjustable jockey rollers. Control of the motor is by push-button from the central control desk, operating through an electromagnetic clutch which disengages the drive when the anchor pins are in approximate alignment with the holes in the frame. The whole of the weight of the grip head is supported on a heavy disc-spring mounting, and the head is thus clear of the machine bed on its rollers when it is being traversed. When the stretching load is applied there is a component of force which compresses the springs and pulls the grip head down on to the bed, where it is supported over a large area.

When the grip head has been drawn into approximate alignment with the holes in the bed the anchor pins are pushed home hydraulically. The pins are chromium-plated and are slightly tapered at the ends to provide a "lead-in." Stationary hydraulic rams are mounted in the grip head, and when pressure is applied the locking pins, which are themselves the cylinders, are pushed outwards to engage in the holes. They are retracted when required by reversing the flow of the hydraulic fluid. The motor-driven pump for operating the locking gear and grip heads operates at a maximum pressure of 4,000 lb. per square inch. It is mounted on the top of the grip-head carriage, and solenoid-operated valves are provided, with push-button controls on the central desk. A spring-loaded cable reel and a cable between the side frames are used to connect the power and control circuits for the pump and motor.

HYDRAULIC GRIP HEADS

The grip heads, which in their gripping members are identical at both ends of the machine, are of the Bigwood patented sectional grip type, the construction of which can be seen in Fig. 4. The top and bottom grip blades are of special-quality steel, and are carried in segmental blocks riding on hardened and ground steel rollers, which bear on hardened and ground inclined steel faces, which are replaceable to allow for wear. The blade segments are 12 in. long and their design permits of easy replacement or interchangeability with blades of different forms, or with different serration patterns. It also allows for an exceptionally wide thickness range of $\frac{1}{16}$ in. to $1\frac{3}{8}$ in. (4 mm. to 35 mm.) with one set of grips. The grip assemblies are operated by hydraulic cylinders and rams, one on each grip head, connected through a system of equalising links. Push-button control from the desk, operating through solenoid valves, enables the grip jaws to be opened and closed as required.

To deal with sheets which are badly buckled, the hydraulically-operated pre-flattening rolls are provided at each grip head (Fig. 4). These consist of a bottom roll and housing which can be adjusted for height by means of a hand-wheel, and a top roll which can be lifted or lowered hydraulically. The bottom roll housing is carried on a pair of housing screws, and hand-wheels, coupled by a roller chain, are provided at each side of the grip head for adjustment purposes. The top roll is directly coupled by means of a beam to a hydraulic cylinder, and a ratchet hand-lever is fitted to the end of the roller shaft. To deal with buckled sheets the top roll is raised to its upper limit of travel under the control of a push-button, and the bottom roll is adjusted by hand to suit the thickness of the sheet, the end of which is then placed on the roll. The top roll is then loaded hydraulically to flatten the end of the sheet, and the hand-lever is used to feed the sheet forward into the jaws, which are open to receive it. The jaws are then closed, and the top roll is raised clear of the sheet. Finally, the other end of the sheet is gripped, the same procedure being adopted, and the stretching can then commence.

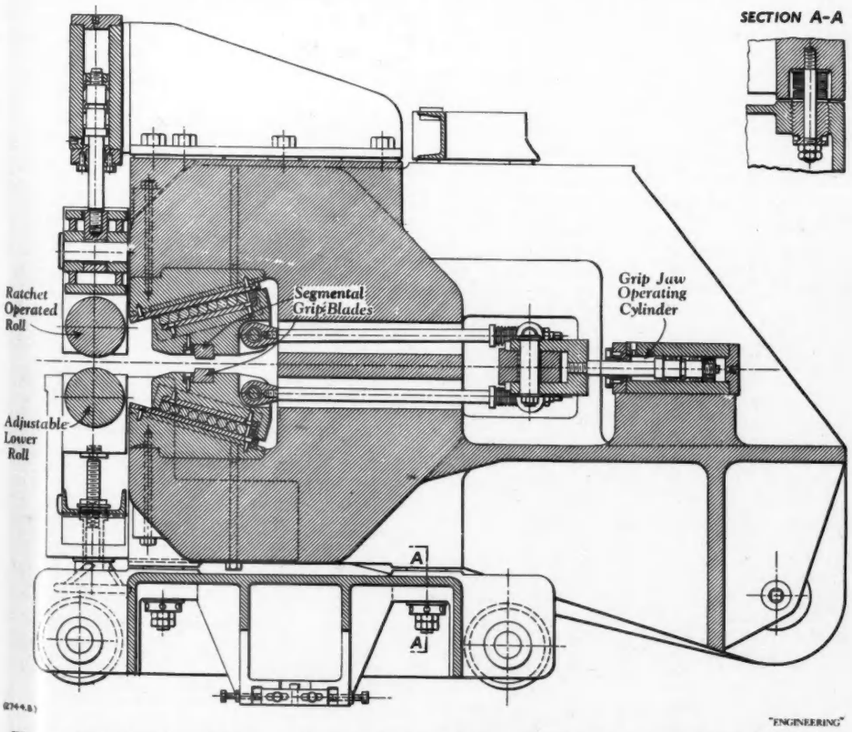


Fig. 4 Showing the gripping mechanism in the adjustable grip head. A similar arrangement is used in the stretching grip head. The pair of rolls in front of the gripping blades are used for preliminary flattening of badly buckled plates.

LOAD APPLICATION

The load-applying unit (Fig. 5), which is served by a Towler double hydraulic pump with an 80-h.p. squirrel-cage motor, consists of a fixed main cylinder and ram, and a secondary ram

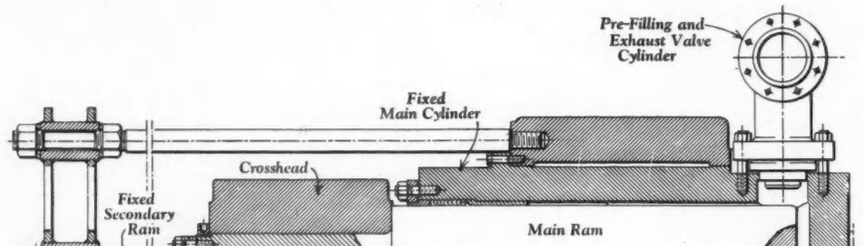


Fig. 5 The main hydraulic cylinder and ram, the crosshead of which is linked to the stretching head.

and cylinder which provide the " take-up " and return motions. The main cylinder is machined from a hollow steel forging, and anchored to the frame by heavy pins. The main ram is bored to form a secondary cylinder, which operates on a fixed secondary ram. The external appearance of this part of the machine can be seen in Fig. 2. Two heavy steel draw-links couple the main ram to the stretching grip head, and the overhung weight of the ends of these links and of the crosshead which connects them to the ram is taken by rollers running on the machine bed. Chevron packings are used on the stretching unit, which works at a maximum pressure of 5,000 lb. per square inch. There are two identical pumps, each with five plungers, and each capable of operating the ram at half speed. A by-pass

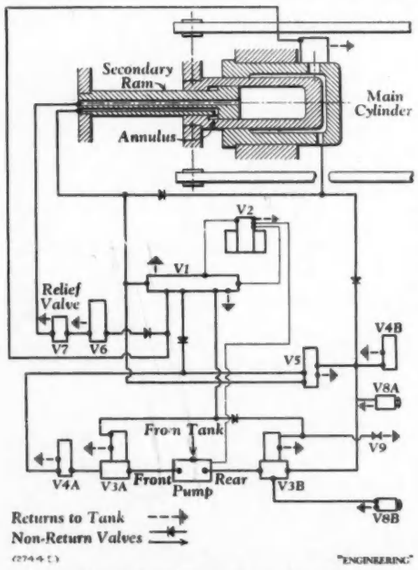


Fig. 6 The hydraulic circuit enables a comparatively low pressure (2,000 lb. per sq. in.) to be used to take up the slack and a high pressure (5,000 lb. per sq. in.) to be used to apply the stretching load. The changeover from one to the other is automatic.

valve enables either or both of these pumps to be used as required.

The outwards or stretching stroke is in two stages: (1) a pressure of 2,000 lb. per square inch is admitted to the annulus of the secondary ram, and this causes the main ram to be drawn back until the slack in the sheet is taken up; (2) an increased resistance, caused by the material coming under load, then effects the change-over to full working pressure of 5,000 lb. per square inch, which is applied to both the annulus and the main ram. The ram continues to move outwards until the required strain has been applied to the sheet. If desired, the sheet can be held at any chosen strain by setting the control valve in the neutral position, and so locking the hydraulic cylinders. To return the ram and grip head to the rest position the main cylinder and annulus are opened to exhaust and a pressure of 500 lb. per square inch is admitted to the secondary ram.

AUTOMATIC CHANGE-OVER

Operation of the stretching grip head can be followed by reference to the circuit diagram, Fig. 6. During the " take-up " part of the stroke, oil is delivered by the front section of the pump to the annulus through the amplifier valve V3A, the calibrated variable pressure relief valve V4A, and the control valve V1. The latter is set by a solenoid-operated pilot valve V2, which is under the control of push-buttons on the desk. Oil is admitted to the main ram cylinder for pre-filling through a pressure-operated pre-filler valve, and from the rear section of the pump through the amplifier valve V3B. When the stretching load is reached, the pre-filler valve closes, pressure rises in the annulus, and the fixed-pressure automatic admission valve V5 lifts to admit oil at a pressure of up to 5,000 lb. per square inch to the annulus and the main ram. The stretching speed is controlled down to 12 in. per minute by manipulating the metering valves V8A and V8B, which by-pass a proportion of the oil to the pump tank. Slower speeds can be obtained, if required, by by-passing the output of the rear pump completely through valve V9.

To return the ram to its inner position after the sheet has been stretched, the control valve admits oil at 500 lb. per square inch through the fixed pressure relief valve V6 to the secondary cylinder. The annulus then exhausts through the control valve V1 into the secondary cylinder, and the main cylinder exhausts through valve V1 to the tank.

GROUPED CONTROLS

Complete control of the machine is exercised from the central control desk (Fig. 7), which can be placed in any convenient position. On the present machine it is located adjacent to the main ram and pump, and raised above floor level to give the operator a clear view of the work in progress. All movements are controlled by push-button, and the setting of each control is indicated by coloured lights on the panel. Interlocking is provided so that the adjustable-head grips can only be operated when the anchor pins are in position in the frame, and the pins cannot be operated unless the grip head is positioned correctly in relation to the anchor holes. The main pump motor is controlled by a separate star-delta starter. In addition to the control push-buttons there are Magslip-operated indicators to show the position of the movable head, and to indicate, independently on the same dial, the amount of extension to which the sheet has been subjected.

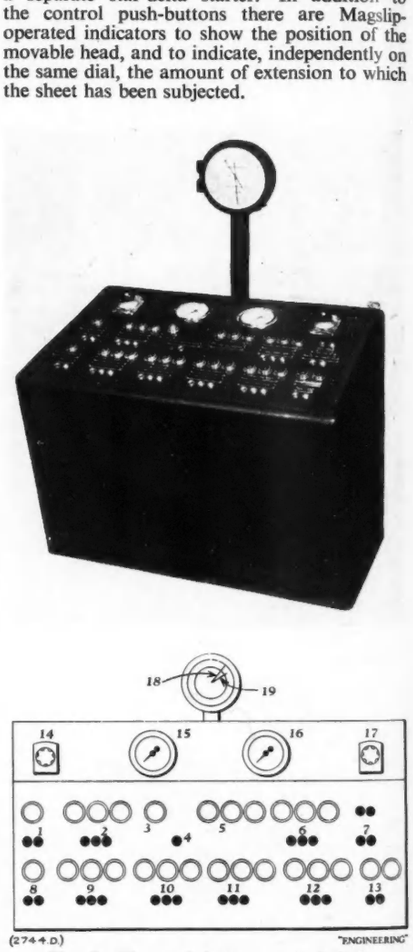


Fig. 7 The push-button control desk.

(1) Stretching grip-head pump unit, on-off control and indicator lights.
(2) Stretching grip-head pinch rolls, raise-neutral-lower control and indicator lights.
(3) Main-pump indicator light.
(4) Stretch-indicator return control.
(5) Grip-head alignment indicator, in—in line—out.
(6) Adjustable grip-head pinch rolls, raise-neutral-lower control and indicator lights.
(7) Grip-head adjusting motor control, forward-reverse-inching.
(8) Adjustable grip-head pump unit control, on-off and indicating light.
(9) Stretching grip-head grip control, grip-neutral-release and indicator lights.
(10) Main ram controls, load—hold on—release and indicator lights.
(11) Adjustable grip-head anchor pin control, in-neutral-out and indicator lights.
(12) Adjustable grip-head grip control, grip-neutral-release and indicator lights.
(13) Adjustable grip-head adjusting-motor clutch control, in-out and indicator lights.
(14) Stretching speed control valve.
(15) Take-up pressure indicator.
(16) Elongation load indicator.
(17) Stretching speed control valve.
(18) Strain indicator.
(19) Adjustable grip-head position indicator.

LAUNCHES AND TRIAL TRIPS

M.S. "SOUTHERN SATELLITE."—Single-screw oil tanker built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Chr. Salvesen & Co., Edinburgh. Third vessel supplied to these owners. Main dimensions: 525 ft. between perpendiculars by 71 ft. by 39 ft. 3 in.; deadweight capacity, about 17,500 tons on a summer draught of 30 ft. 6¼ in.; oil-cargo capacity, about 16,450 tons. N.E.M.-Doxford six-cylinder single-acting two-stroke opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 15 knots in service. Launch, February 8.

M.S. "VASAHOLM."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, for the Swedish-American Line, Gothenburg, Sweden. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 38 ft. 6 in. to shelter deck; deadweight capacity, about 8,500 tons on a draught of 25 ft. 8 in.; cargo-carrying capacity, 545,000 cub. ft. (including 35,000 cub. ft. refrigerated space). Eriksbergs-B. & W. seven-cylinder two stroke single-acting Diesel engine, developing 8,300 b.h.p. Service speed 17 knots, fully loaded. Launch, February 8.

M.S. "P.5."—Off-shore patrol vessel, built and engined by Chantiers et Ateliers Augustin Normand, le Havre, for the French navy. Main dimensions: 173 ft. 8⅛ in. by 22 ft. 10⅛ in. by 6 ft. 8 in. (mean draught); displacement, 380 tons. Four Diesel engines, coupled to two shafts, developing a total of 3,500 h.p. Speed, 18·7 knots. Launch, February 9.

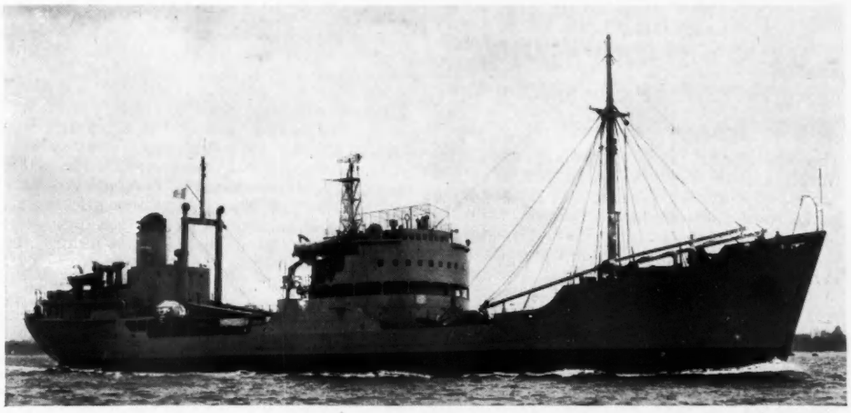
M.S. "MORGENEN."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for A/S Tanktransport (Manager: Thorvald Berg), Tonsberg, Norway. Main dimensions: 512 ft. between perpendiculars by 72 ft. 6 in. by 41 ft. 2 in.; deadweight capacity, about 18,400 tons on a draught of 30 ft. 8⅜ in. N.E.M.-Doxford six-cylinder opposed-piston oil engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 14¾ knots. Engine arranged for burning heavy oil. Trial trip, February 9 and 10.

S.S. "MARBELLA."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, to the order of J. Marr and Sons, Ltd., Hull. Second of two sister ships for these owners. Main dimensions: 189 ft. by 32 ft. by 16 ft. 3 in.; gross tonnage, about 800. Triple-expansion steam engine and one oil-fired boiler, constructed and installed by Charles D. Holmes & Co., Ltd., Hull. Launch, February 11.

M.S. "VESTVARD."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for Klosters Rederi A/S (Manager: Lauritz Kloster), Oslo, Norway. Main dimensions: 555 ft. 9 in. overall by 71 ft. by 39 ft.; deadweight capacity, about 18,178 tons on a draught of 29 ft. 8¼ in. Kincaid-Harland and Wolff-Burmeister & Wain seven-cylinder single-acting opposed-piston oil engine, developing 7,600 b.h.p. at 110 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Speed on trial, 15·6 knots, fully loaded. Trial trip, February 18.

S.S. "POTOSI."—Single-screw cargo vessel, with accommodation for twelve passengers, built by the Greenock Dockyard Co., Ltd., Greenock, for the Pacific Steam Navigation Co., Liverpool. Third vessel of this type for these owners. Main dimensions: 476 ft. between perpendiculars by 66 ft. by 40 ft. 8 in.; gross tonnage, about 8,500; deadweight capacity, about 11,100 tons on a mean draught of 28 ft. Reaction steam turbines with double-reduction gearing, developing 9,400 s.h.p. at 108 r.p.m. in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne. Steam supplied by two oil-fired water-tube boilers, constructed by Babcock and Wilcox Ltd., London, E.C.4. Machinery installed by John G. Kincaid & Co., Ltd., Greenock. Speed, 16½ knots in service. Launch, February 23.

M.S. "LEEDS CITY."—Single-screw cargo vessel, built and engined by William Doxford and Sons, Ltd., Sunderland, for Sir William Reardon Smith and Sons, Ltd., Cardiff. Second vessel of a series of four for these owners. Main dimensions: 436 ft. 6 in. between perpendiculars by 59 ft. 2½ in. by 28 ft. 8 in.; deadweight capacity, about 9,300 tons on a draught of 25 ft. 5½ in. Doxford four-cylinder opposed-piston oil engine, developing 4,400 b.h.p. at 100 r.p.m. Speed on service, 13¼ knots. Launch, February 23.



PERUVIAN OIL TANKER "SECHURA"

The oil tanker Sechura, which has been built for the Peruvian Navy at the Woolston shipyard of John I. Thornycroft and Company, Limited, was handed over on February 15, in the presence of Their Excellencies Señor Dr. Don Ricardo Rivers Schreiber, the Peruvian Ambassador, and Señora Teresa Rivers Schreiber, to her commanding officer, Comandante Luis E. Vargas.

A brief description of the vessel was given in ENGINEERING of November 26, 1954, but, as certain of these particulars were based on design figures, some of them may now be amplified in the light of the trial results. The main dimensions are: 385 ft. in length overall, breadth moulded 52 ft., depth moulded 26 ft., and service displacement 8,700 tons when carrying a deadweight cargo of 6,000 tons of oil. The vessel has been built to the highest classification of Lloyd's Register for carrying petroleum in bulk, and complies also with the regulations of the United States Coast Guard and those of the International Convention for the Safety of Life at Sea. She conforms to the usual tanker arrangement in having the machinery aft, a long poop in which the crew is accommodated, and a central bridge structure in which are the quarters for the captain and officers.

The cargo space is divided by two corrugated longitudinal bulkheads, extending from the cofferdam at the forward end of the engine room to the forward cofferdam, in which the foremast is stepped; and six intermediate transverse bulkheads, which are also corrugated, out to the turn of the bilge. This subdivision provides 18 main cargo tanks. The aftermost space, which would correspond in position to No. 7 tanks, is occupied by the main pump-room in the centre and two small tanks in the wings. Forward of the forward cofferdam is a hold for dry cargo and beneath it two tanks, port and starboard, which can be used for oil fuel or water ballast. Water ballast is also carried in the fore-peak, above which is a space for stores. Between the after cofferdam and the forward engine-room bulkhead are tanks containing, on the port side, fuel for the main Diesel propelling engine, and on the starboard side, oil fuel for the two Scotch boilers supplying auxiliaries.

The main engine has been supplied by Burmeister and Wain, Copenhagen, and is a five-cylinder direct-reversing single-acting two-stroke unit of the crosshead type, developing 2,400 h.p. at 120 r.p.m., corresponding to a loaded sea speed of 12 knots. On trial, a speed of 13¼ knots was attained. The engine drives a four-bladed right-handed bronze propeller, 14 ft. 3 in. in diameter. The propeller shaft, 13⅞ in. in diameter over the liner, is fitted with Cedervall shaft glands. The main-engine salt-water, fresh-water and lubricating-oil pumps are chain-driven from the shaft abaft the thrust block.

On a main-deck flat forward of the engine casing are two two-furnace single-ended cylindrical boilers, supplied by Messrs. Thornycroft. They are 12 ft. in diameter and 10 ft. 10½ in. long, and are oil-fired by means of a Weir duplex heating unit with two pumps, each capable of supplying 2,500 lb. of oil per hour at 325 lb. per square inch. The steam, which is used for cargo-tank cleaning and heating as well as for the steam-driven auxiliary machinery in the engine room and on deck, and the cargo-oil pumps, is supplied at a pressure of 180 lb. per square inch. The funnel is of Messrs. Thornycroft's patented design, the form of which is clearly seen in the accompanying illustration.

Most of the engine-room auxiliaries are steam-driven. Those supplied by G. and J. Weir, Limited, comprise two boiler-feed pumps; two oil-fuel transfer pumps; a ballast and stand-by salt-water pump; a standby fresh-water cooling pump; a bilge and general-service pump; a fire and bilge pump; and a standby lubricating-oil pump.

The electricity generating plant consists of three units, two of 50-kW output, and a standby emergency set of 12 kW, all generating direct current at 110 volts. Of the two 50-kW sets, one is turbine-driven and was supplied by W. H. Allen, Sons and Company. The other is driven by a Gardner Diesel engine of 81 brake horse-power, running at 800 r.p.m. The standby set, also supplied by Norris, Henty and Gardner Limited, has a 24-h.p. engine. Both the Diesel-driven sets are fitted with heat exchangers.

The cargo pumping system has been so arranged as to provide the maximum flexibility in dealing with mixed cargoes for discharge at two or more ports without danger of contamination, the tank vents being so designed that gas from one tank cannot pass into any of the others. In the main pump room there are two duplex horizontal cargo-oil pumps, supplied by J. H. Carruthers and Company, Glasgow, each capable of handling 300 tons per hour against a pressure of 150 lb. per square inch. In the same pump room there are two Weir pumps, delivering 40 tons per hour at 40 lb. per square inch, for handling special oil products; and a Weir pump for bilge pumping and cargo-water drainage.

Because of the heavy swell frequently experienced in the waters where the ship will operate, attention has been given to the arrangements for securing vessels alongside when fuelling at sea, provision being made for six head and six stern lines of 10-in. Manila rope, led through roller fairleads to fabricated bollards. Roller bow stoppers are fitted for the chain cables. For handling dry cargo, there are two 7-ton derricks on the foremast and a 12-ton derrick for dealing with deck cargo. The principal contractors for the deck machinery are Clarke, Chapman and Company, and the American Engineering Company.

The navigating equipment includes a Sperry gyro-compass, a Chernikeeff log, and echo-sounding, radar and direction-finding installations. The wireless equipment comprises high-frequency, medium-frequency and low-frequency sets, and there is a sound-reproducing installation.

ENGINEERING IN LONDON TRANSPORT

Report of the Committee of Inquiry

The report* of the independent inquiry into the workings of the London Transport Executive is necessarily primarily concerned with service given to the travelling public and with the financial results of operating London's road and rail passenger system. The committee did examine, however, the engineering background in considerable detail, and their account and recommendations indicate a number of technical developments which would have to be undertaken in order to gain improvements in the system. What could be the most significant means of improving the engineering operations of the Executive is discussed in Weekly Survey.

Of the large-scale improvements required, the committee were outspoken on the need for road improvements in the central London area and on the desirability of going ahead with the construction of at least one new underground (tube) railway. Both require decisions at Government level.

Of the construction of a new tube—a specific reference is made to the proposed route C (see Weekly Survey of February 18)—the committee said that " while it is necessary to keep well in mind the immediate financial results of any new capital expenditure, the indirect economic advantages to London Transport and to London's economy as a whole are so important that a project of this kind should not be abandoned or postponed because on the basis of direct revenue and direct expenditure it appears to be unprofitable." In the same paragraph the committee stated that, in central London, an electric railway (which must perforce be underground) is a more efficient means of transport than road vehicles.

Noting that power is the highest single item in the cost of train operation, and that consumption is almost directly proportional to the weight of the train, the committee applauded the practice of uncoupling parts of the train during off-peak hours. The use of rolling stock of light alloys was recommended, but at the same time the Executive were upheld in their decision not to order such stock in numbers until improved designs were available.

Of the factors contributing to the efficiency of operation during peak periods, two mentioned in the report related to the trains themselves and one to the station layout. In the last respect, the committee emphasised the importance of station layout which allowed movement of the passengers and the use of longer trains when required. Of the trains, the relevant factors were the speed and length of the trains and their powers of acceleration and braking, and the minimum headroom that could be attained with safety. The first of these two factors is closely related to the use of light-alloy coach construction and the extended use of regenerative braking, and the second with the effectiveness of the signalling system. With the extended use of a recent innovation, the committee found it difficult to visualise any further improvement being possible in this direction.

Of road-service vehicles the committee were of the opinion that maintenance costs were too high. It was agreed, however, that the highest standards of maintenance, compatible with a reasonable expenditure, should be effected and it was acknowledged that the standards now obtaining were probably as high as in any other city in or out of the United Kingdom. Nevertheless, the committee were severely critical of the trade unions' approach which caused far too large a labour force to be employed.

In considering the expenditure by London Transport on research, only £50,000 per annum, it was pointed out that the provision of regular services for a number of passengers which could not materially fluctuate did not lend itself to spectacular developments of the kind sometimes possible in industry. Furthermore, it was always possible for the Executive to get research work done by the makers and suppliers of their equipment, including research along lines suggested by operating experience.

After considering all the evidence the committee were satisfied that the decision to abandon the trams in favour of oil buses and trolley-buses had been correct. Moreover, the committee upheld the intention of the Executive to replace the trolley-buses by oil buses. There was little to pick between the operating costs of the two types of vehicle but the heavier capital costs involved in the trolley-buses (including that of power stations which would require to be rebuilt if their use was continued) and the greater flexibility of the oil buses made the latter the most suitable road vehicle for use in London. One-man operated vehicles were not found to be suitable for operation in the central areas.

The arrangements and facilities to cope with peak-hour crowds at some central-area stations were found to be insufficient, but the Executive were supported in their opinion that the cost of reconstruction could not be incurred except where the station was to be rebuilt as part of the work of driving a new tube. Suggestions are made in the report, however, for the greater consideration to be given to the provision of covered inter-change between buses and trains, at Victoria and at Kings Cross, in particular.

* * *

WATER METERS FOR TRADE SUPPLIES

A new range of water meters for trade supplies, known as the " Master " range, has been developed by George Kent, Limited, Luton, Bedfordshire. The Master meter is designed for measuring accurately water flows at temperatures not greater than 120 deg. F., and the manufacturers claim that, compared with earlier types of water meter, it has a greater discharge capacity for a given size, due to streamlined flow passages, a lower head loss for a given flow, and considerably less weight. The overall accuracy is within 2 per cent.

Fig. 1 One of the Master range of water meters, which are of the rotary-piston type and are available in 1½-in., 2-in., 3-in. and 4-in. sizes.

The Master meter (Fig. 1) is a pipe-line semi-positive rotary-piston meter, constructed in durable corrosion-resistant materials. The rotary-piston principle embodied in Kent water meters since 1922 gives excellent performance at low rates of flow as well as high, and is illustrated in Figs. 2—5. Between the water-inlet and outlet ports in the working chamber is a division piece which constrains the motion of the hollow piston, the spindle of which moves in a circular path and drives a gear train.

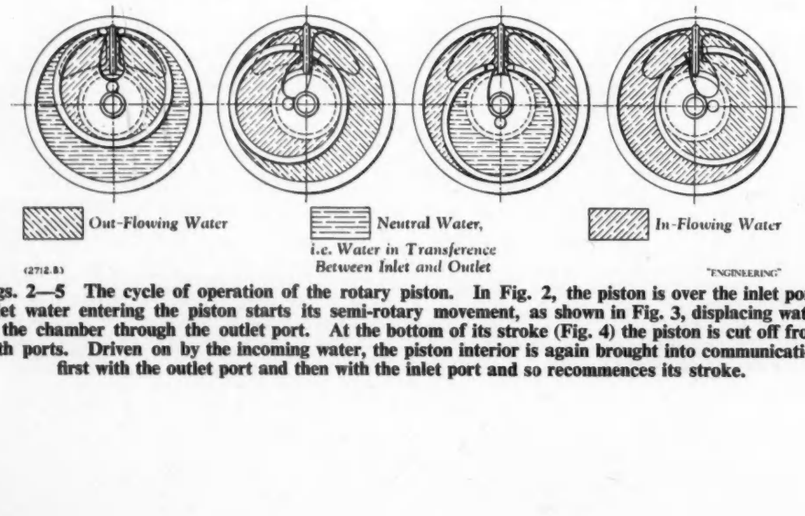
In Fig. 2, which shows the piston over the inlet port, inlet water enters the piston and causes it to start its semi-rotary movement, sliding down the division piece and displacing the " neutral " water in the body of the working chamber through the outlet port, as shown in Fig. 3. In Fig. 4, the piston is at the bottom of its stroke and is cut off from both ports. Fig. 5 shows the finish of the exhaust, the inside of the piston again being connected with the outlet, and inlet re-commencing.

The meter is built up of five main components: the outer casing or body, the working chamber, the reducing gear or undergear, the counter, and the counter box. The working chamber and gear train are separate and replaceable. The body and cover are high-grade grey cast iron, treated with bitumastic solution to prevent corrosion. The cover, when bolted on to the body, clamps the working chamber in its correct position. Arrows on the cover and on the side of the body indicate the correct direction of flow through the meter.

The working chamber and its top plate are machined from cast bronze, and the piston and thimble inside are of ebonite. A nickel-plated copper strainer in the inlet pipe prevents foreign matter from entering the meter. The undergear is common to all sizes of Master meter, the gears being made of nickel, since the train is submerged in water when working. The piston-spindle and hub-spindle are also of nickel.

The counter is of cyclometer pattern, the counter-gear number rollers being made in non-corrodible white plastic with figures in black. A pointer is provided for the indication of small quantities. Change-wheel facilities are accommodated in the counter unit. The dial of the meter is vitreous-enamelled copper, with indestructible markings clearly legible. The counter box is a brass stamping. Sealing holes and lugs are provided to prevent unauthorised interference with the meter.

Master meters are made in 1½-in., 2-in., 3-in. and 4-in. sizes, with capacities at 33-ft. w.g. head loss, of 3,000 gallons, 5,000 gallons, 9,000 gallons and 16,000 gallons per hour respectively. The 1½-in., 2-in. and 3-in. sizes have a maximum counter registration of 10 million Imperial gallons, and the 4-in. model has a maximum of 100 million Imperial gallons. The meters can be calibrated in any desired unit. The 1¼-in. gauge commences to register at 3 gallons per hour and the 4-in. gauge at 15 gallons per hour.



Figs. 2—5 The cycle of operation of the rotary piston. In Fig. 2, the piston is over the inlet port. Inlet water entering the piston starts its semi-rotary movement, as shown in Fig. 3, displacing water in the chamber through the outlet port. At the bottom of its stroke (Fig. 4) the piston is cut off from both ports. Driven on by the incoming water, the piston interior is again brought into communication first with the outlet port and then with the inlet port and so recommences its stroke.

* *Report of the Committee of Inquiry into London Transport.* H.M. Stationery Office. [5*s.* net].

Labour Notes

T.U.C. ON DIVIDENDS

Following their annual custom in recent years, the General Council of the Trades Union Congress submitted proposals to the Chancellor of the Exchequer last week in connection with the forthcoming Budget. It was noteworthy that suggestions for further increases in the taxation of profits formed a substantial part of the advice tendered to the Chancellor.

In their letter to Mr. R. A. Butler, the General Council put forward the view that the effects of the Government's decontrol policies, and of its tax reliefs in favour of business, were clearly noticeable last year in the trend of speculation on the Stock Exchange, the number of bonus issues of shares, and the further large increase in dividends.

There could be no doubt, the General Council submitted, that it was shareholders who had reaped the greatest relative rewards from recent improvements in the country's fortunes. No one should be surprised, therefore, if there were demands from trade unionists for a " fair share in the prosperity created by their efforts."

Statements by Ministers regarding the need for restraint to be exercised in respect to the distribution of dividends were useless unless backed by positive action. " A most disquieting feature of 1954," the General Council affirmed, had been the priority which the Government had continued to give to its " doctrinaire aim of restoring a private-enterprise economy."

TAXATION SUGGESTIONS

Although profits rose steeply last year, and although a further rise during 1955 seemed more than likely, the General Council wrote to Mr. Butler, the abolition of the excess profits levy and the operation of investment allowances would almost certainly result in a fall in tax revenue from industry during the present year.

There could be no justification for this in the present circumstances. Both to secure revenue and to check further increases in dividends, the General Council stated, they urged that the tax on undistributed profits should be increased. It was also suggested that a tax should be levied on realised capital gains.

Other proposals put forward by the General Council were that the age limits for the repayment of post-war credits should be progressively lowered, that the purchase tax on clothing and essential household goods should be reduced, and that the tax on fuel used by commercial road vehicles should be decreased.

The inference is not unlikely to be drawn in some quarters, from the comments of the General Council regarding profits and fair shares, that a new wave of wage demands may be in contemplation by the trade-union movement.

ELECTRICIANS' STRIKE BALLOT

According to an announcement by the employers' organisation, the National Federated Electrical Association, on February 24, an agreement has been reached with the Electrical Trades Union for an increase in the wage rates of operatives in the electrical-contracting industry.

As from Monday, March 14, the wages of journeymen electricians will be increased by 3*d.* an hour and there will be proportionate increases in the rates for other classes of employees. In all, it is estimated that the earnings of about 40,000 persons will be affected.

In consequence of this agreement, arrangements for the taking of a ballot vote of its membership, on whether or not strike action should be begun on its wage claim, which was announced by the union on February 16, have been cancelled.

The decision to hold a strike ballot had been taken by the union's executive council at a meeting which had had under consideration an offer from the employers' Federation of an additional 2*d.* an hour in settlement of the union's demand for higher wages.

In the course of a statement on the position, at the time of the decision to hold a strike ballot, the union's council stated that it had found the employers' offer (of an extra 2*d.* an hour) to be " totally inadequate " for the men's needs.

ROAD-HAULAGE EMPLOYEES' WAGES

The Road Haulage Wages Council unanimously decided at its meeting in London on February 25 to give notice to employers in the industry of its intention to submit certain wage proposals to Sir Walter Monckton, the Minister of Labour and National Service. These will take the form of amendments to existing Orders under the Wages Councils Act, which fix the statutory minimum remuneration for road-haulage employees whose conditions of employment come within the scope of the Wages Council.

The Council proposes that the legal minimum basic wage shall be increased by 10*s.* a week in the case of adult employees and those juveniles to whom existing adult rates apply, by 7*s.* 6*d.* a week for lads aged between 18 and 20 years, and by 5*s.* a week for boys under 18 years of age. The Council is also of the opinion that the addition for each hour of night work should be increased from 6*d.* to 8*d.*

Notices containing full details of the proposals will be sent in the near future to all employers in the industry and a period of 14 days will be allowed for the receipt of representations with respect to the suggestions. Any representations lodged within that period will be considered at a subsequent meeting of the Council, at which the question of submitting the proposals to the Minister of Labour and National Service for the making of an Order to give effect to them will be further discussed.

ENGINEERING STAFFS' PAY CLAIMS

Demands for increased rates of pay for scientific staffs and clerical employees in the engineering and associated industries were presented to the Engineering and Allied Employers' National Federation, at separate meetings, on February 22, by trade unions representing these grades.

It is understood that both these sections of employees have submitted claims for substantial advances in their basic rates and that they have asked for their graded incremental scales to be increased in proportion.

The employers' Federation stated, in each case, that it would give careful consideration to the claims and that its reply would be submitted to the unions at a later date.

It was also announced on February 22 that the reply of the employers' Federation to the wage claim of the Confederation of Shipbuilding and Engineering Unions for increases of 15*s.* a week on the basic rates for skilled men, and of 10*s.* a week on those of unskilled employees, in the engineering industry, would be announced on Wednesday next, March 9.

INCREASE IN WORKING POPULATION

The distribution of the country's working population throughout the various trades and industries is shown in statistics contained in the February issue of the *Ministry of Labour Gazette*, which was published at the end of last week.

Separate figures are shown for the United Kingdom and for Great Britain, and, although these details relate to the position as it was at the end of May last year, they have advantages over the Ministry's monthly estimates, to which they are largely complementary.

The figures cover all workpeople, including persons who were unemployed and persons who were absent from work owing to illness or other causes, as well as those who were actually at work. Employers and self-employed persons are excluded.

The figures are based mainly on counts of national insurance cards exchanged in the June-to-August quarter, together with information supplied by employers of five or more workpeople as to the total number of insurance cards they hold. For Great Britain as a whole the estimated total numbers of workpeople at the end of May, 1954, were 13,840,000 male employees and 7,350,000 women employees, representing increases since May, 1953, of 120,000 men and boys and of 190,000 women and girls.

DISTRIBUTION IN INDUSTRY

Of the total working population in Great Britain at May, 1954, no fewer than 1,973,610 men, women and juveniles were employed in the engineering, shipbuilding and electrical-goods group of industries. This total comprised 1,545,870 men and boys, and 427,740 women and girls. For the United Kingdom as a whole there were, in all, some 2,013,700 persons employed in these industries.

In the vehicle-building industries, the number of persons employed, in Great Britain only, totalled 1,146,450, of whom 977,640 were men and boys, and 168,810 were women and girls.

The building and contracting industry in Great Britain provided work for a total of 1,352,650 persons, of whom 1,303,490 were men and boys; and another 1,689,410 persons, including 1,443,370 men and boys, found employment in the transport and communications industry. Persons at work in the distributive trades totalled 2,289,400, of whom 1,133,470 were men and boys and 1,155,930 were women and girls.

There were 493,580 workpeople engaged in the metal-goods industry, other than persons included in the figures quoted above; 1,340,910 employees engaged in public administration and defence; 1,587,460 personnel occupied in the professions; and some 1,638,830 persons engaged in miscellaneous services of various kinds, ranging from laundries and dry cleaning to sport and hairdressing.

FEWER CIVIL SERVANTS

Between October 1, 1954, and January 1, 1955, the number of non-industrial Civil Servants declined from 638,176 to 633,380, according to a White Paper entitled *Staffs Employed in Government Departments*, which was published last Friday (Cmd. 9400, H.M.S.O., price 3*d.*)

This reduction, of 4,796 persons in three months, is the net result of reductions in the staffs employed by many different Ministries, partially offset by increases in numbers of persons employed at a small number of other Ministries.

The largest decreases in personnel have taken place at the Ministry of Food, which has 1,439 fewer persons in its employ; at the Ministry of Labour and National Service, which has lost 1,007 of its staff, and which, with a total of 23,277 employees, is now smaller than at any time since April, 1934; and at the Ministry of Pensions and National Insurance, which has 677 fewer employees.

Over 400 persons have been transferred, with their work, from the Ministry of Works to the United Kingdom Atomic Energy Authority.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

BIRMINGHAM
Discussion on "Oils and Greases." Birmingham Branch. Chamber of Commerce, 95 New-street, Birmingham. Wed., Mar. 9, 7.15 p.m.
BRADFORD
"Recruitment and Training of Apprentices for the Engineering Industry," by S. R. Noble. Bradford Branch. Midland Hotel, Bradford. Wed., Mar. 9, 7.30 p.m.
LEEDS
"Power Factor Correction," by L. Brecknell. Leeds Branch. Great Northern Hotel, Leeds. Mon., Mar. 7, 7.30 p.m.
SOUTHAMPTON
Various short papers. Southampton Branch. Polygon Hotel, Southampton. Wed., Mar. 9, 8.15 p.m.
YORK
Discussion on "Electronic Controls." York Branch. Picture House Café, Coney-street, York. Wed., Mar. 9, 7.15 p.m.

British Institution of Radio Engineers

GLASGOW
"Computing Circuits in Flight Simulators," by R. A. Marvin. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Mar. 10, 7 p.m.
NEWCASTLE-UPON-TYNE
"The Application of Negative Feedback to Electrical Measuring Instruments," by F. J. U. Ritson. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Mar. 9, 6 p.m.
WOLVERHAMPTON
"Electrical Standards in Electronics," by P. M. Clifford. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Mar. 9, 7.15 p.m.

Chemical Society

EDINBURGH
"The Changing Face of the Gas Industry," by Dr. A. Marsden. Edinburgh Branch. North British Station Hotel, Edinburgh. Thurs., Mar. 10, 7.30 p.m.
LEEDS
Open Meeting. Leeds Branch. Chemistry Lecture Theatre, The University, Leeds. Thurs., Mar. 10, 6.30 p.m.

Illuminating Engineering Society

LONDON
Trotter-Paterson Memorial Lecture on "The Brightness of the Stars," by Sir Harold Spencer Jones. Royal Institution, Albemarle-street, W.1. Wed., Mar. 9, 6 p.m.
MANCHESTER
Open Meeting. Manchester Centre. Offices of the North-Western Electricity Board, Town Hall, Manchester. Thurs., Mar. 10, 6 p.m.
STOKE-ON-TRENT
"Home Lighting," by Mrs. J. W. Stewart. Stoke-on-Trent Group. Offices of the Midlands Electricity Board, 31 Kingsway, Stoke-on-Trent. Tues., Mar. 8, 6 p.m.

Incorporated Plant Engineers

DUNDEE
Annual General Meeting and Film Evening. Dundee Branch. Mathers Hotel, Dundee. Mon., Mar. 7, 7.30 p.m.
EDINBURGH
Annual General Meeting. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Mar. 8, 7 p.m.
GLASGOW
Annual General Meeting. "Civil-Engineering Problems and Their Solution," by D. Pentland. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow. Wed., Mar. 9, 7 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Mar. 10, 7 p.m.
NOTTINGHAM
Annual General Meeting. East Midlands Branch. Adult Education Centre, Shakespeare-street, Nottingham. Wed., Mar. 9, 7 p.m.

Institute of British Foundrymen

BEDFORD
"Production of Moulds and Cores by the Carbon-Dioxide Process," by Dr. D. V. Atterton. Bedfordshire-Hertfordshire Section. Offices of W. H. Allen, Sons & Co., Ltd., Bedford. Thurs., Mar. 10, 7.30 p.m.
BURNLEY
Annual General Meeting "Shell Moulding and the Economic Use of Shell-Moulding Materials," by R. K. Jackson. Burnley Section. Municipal College, Ormerod-road, Burnley. Wed., Mar. 9, 7.30 p.m.
GLASGOW
Annual General Meeting. "Technical Control in a Mechanised Bronze Foundry," by W. T. Watt. Scottish Branch. Royal Technical College, Glasgow. Sat., Mar. 12, 2.45 p.m.
LINCOLN
"Castings for the Smithy and Forging Industry," by W. S. Spenceley. Lincolnshire Branch. Technical College, Lincoln. Thurs., Mar. 10, 7.15 p.m.
SHEFFIELD
"The Place of Shell Moulding in the Foundry," by Dr. B. H. C. Waters. Sheffield Branch. College of Technology, Pond-street, Sheffield. Mon., Mar. 7, 7.15 p.m.

Institute of Fuel

LONDON
"Fuel Developments in Germany," by Dr. W. Gumz. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Mar. 10, 5.30 p.m.

Institute of Marine Engineers

LONDON
"Application of Modern Instrumentation and Distance Control of Machinery," by R. H. Paddon Row. Tues., Mar. 8, 5.30 p.m.

Institute of Metals

SHEFFIELD
"Place of Shell Moulding in the Foundry," by Dr. B. H. C. Waters. Sheffield Local Section. College of Technology, Pond-street, Sheffield. Mon., Mar. 7, 7.15 p.m.
SWANSEA
"Industrial Methods of Electroplating," by Dr. G.E. Gardam. South Wales Local Section. University College, Singleton Park, Swansea. Tues., Mar. 8, 6.45 p.m.

Institute of Petroleum

LONDON
"The Viscosity of Liquid Hydrocarbons," by L. Grunberg. Wed., Mar. 9, 5.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Trends in Vehicle Compression-Ignition and Petrol Engine Lubrication," by F. Lawrence. Midlands Centre. Crown Inn, Broad-street, Birmingham. Tues., Mar. 8, 7.30 p.m.
BRISTOL
"Road and Rig Testing of Prototype Road-Transport Vehicles and Their Components," by J. Alden. Western Centre. Grand Hotel, Bristol. Thurs., Mar. 10, 7.30 p.m.
EDINBURGH
"Steering Geometry and Wheel Balance," by A. J. Hardman. Scottish Centre. North British Station Hotel, Edinburgh. Mon., Mar. 7, 7.30 p.m.
MANCHESTER
Discussion on "Lockheed Hydraulic Servo Systems." North-West Centre. Engineers' Club, Albert-square, Manchester. Mon., Mar. 7, 7.30 p.m.

Institute of Welding

LONDON
"Plurial Welding Process," by M. Lebrun. South London Branch. 2 Savoy-hill, W.C.2. Thurs., Mar. 10, 6.30 p.m.
LINCOLN
"Economics of Welding," by H. Martin. East Midlands Branch. Lincoln Technical College, Lincoln. Fri., Mar. 11, 7.15 p.m.
SHEFFIELD
"The Place of Radio-Active Isotopes in Non-Destructive Testing," by G. F. Gribbin and R. S. Forbes. Sheffield Branch. Sheffield College of Commerce and Technology, Sheffield. Mon., Mar. 7, 7.15 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Instrument Performance in Industrial Applications," by J. Illingworth. Midlands Branch. The University, Edmund-street, Birmingham. Wed., Mar. 9, 6.30 p.m.
MANCHESTER
Discussion on "Pilot Plant and Scale-up Problems." North-Western Branch. The College of Technology, Manchester. Sat., Mar. 12, 2.30 p.m.

Institution of Civil Engineers

LONDON
"The Civil Engineer and Britain's Atomic Factories," by D. R. R. Dick. Structural Engineering and Building Division. Tues., Mar. 8, 5.30 p.m.
BIRMINGHAM
"The Engineer and the Law," by G. L. Boucher. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Mar. 10, 6 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "What is the Future of the Steam Locomotive?" opened by C. M. Cock. Mon., Mar. 7, 5.30 p.m.
"Artificial Reverberation," by Dr. P. E. Axon, C. L. S. Gilford and D. E. L. Shorter. Radio Section. Wed., Mar. 9, 5.30 p.m.
"The Electrical Equipment of the Toronto Subway Cars," by F. W. Roberts. Extra Meeting. Thurs., Mar. 10, 5.30 p.m.
ARBORFIELD
"The Development of Fluorescent Tube Control," by G. V. McNeill. London Students' Section. R.E.M.E. Training Centre, Arborfield, Berkshire. Tues., Mar. 8, 7 p.m.
BIRMINGHAM
"Short-Circuit Forces on Turbo-Alternator End Windings," by J. B. Young and D. H. Tompsett. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Mar. 7, 6 p.m.
CARDIFF
"Proving the Performance of Circuit-Breakers, with Particular Reference to Those of Large Breaking Capacity," by J. Christie, H. Leyburn and J. F. Bird. Western Centre. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Mar. 7, 6 p.m.
LIVERPOOL
"A Criterion of Distribution Cost," by D. J. Bolton. Mersey and North Wales Centre. Royal Institution, Colquitt-street, Liverpool. Mon., Mar. 7, 6.30 p.m.
NOTTINGHAM
Junior Members' Evening. East Midland Centre. Gas Department's Offices, Nottingham. Tues., Mar. 8, 6.30 p.m.
PORTSMOUTH
"The Manchester-Kirk o'Shotts Television Radio-Relay System," by G. Dawson, L. L. Hall, K. G. Hodgson, R. A. Meers and J. H. H. Merriman. Southern Centre. Portsmouth College of Technology, Portsmouth. Wed., Mar. 9, 6.30 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Launching of Ships," by R. Allan. North-East Branch. Northern Architectural Association, 6 Higham-place, Newcastle-upon-Tyne. Mon., Mar. 7, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Design of Wake-Adapted Screws and Their Behaviour Behind the Ship," by Professor W. P. A. van Lammeren and Dr. J. D. van Manon. Tues., Mar. 8, 7.30 p.m.

Institution of Heating and Ventilating Engineers

NEWCASTLE-UPON-TYNE
"The Prevention of Smoke from Heating Boilers," by T. F. Hurley and L. J. Flaws. North-East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Mar. 8, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
Annual General Meeting. "The Railbus," by E. Kreissig. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Mar. 9, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
"Analysis and Interpretation of Service Records," by A. T. Wilford. Automobile Division. Tues., Mar. 8, 5.30 p.m. Discussion on "The Engineer as an Administrator." Industrial Administration and Engineering Production Group. Thurs., Mar. 10, 6.45 p.m.
"Heavy-Duty Truck Development in the United States," by Robert Cass. James Clayton Lecture. Fri., Mar. 11, 5.30 p.m.
DUNDEE
"The Development and Scope of Work Study," by R. M. Currie. Scottish Branch. Technical College, Dundee. Fri., Mar. 11, 7.30 p.m.
GLASGOW
"The Development and Scope of Work Study," by R. M. Currie. Scottish Branch. Royal Technical College, George-street, Glasgow. Thurs., Mar. 10, 7.30 p.m.

Institution of Production Engineers

BLACKBURN
Annual General Meeting. "Selection and Training of Engineering Apprentices," by E. K. Langham. Preston Section. Crown Hotel, Market-place, Blackburn. Wed., Mar. 9, 7 p.m.
CHATHAM
Annual General Meeting, 7 p.m. "Layout and Machinery Required for Production of Clothing," by W. Bland, 7.30 p.m. Rochester Section. Sun Hotel, Chatham. Thurs., Mar. 10.
DONCASTER
"Applications of Rubber to Engineering," by J. P. Holdsworth. Doncaster Section. Danum Hotel, Doncaster. Tues., Mar. 8, 7 p.m.
LEICESTER
"Measure of Progress," by F. G. S. English. Leicester Section. Bell Hotel, Leicester. Thurs., Mar. 10, 7 p.m.

Institution of the Rubber Industry

LONDON
"Changes in Rubber-Like Materials by Exposure to High-Energy Radiation," by Dr. A. Charlesby. London Section. Oversea League, Park-place, St. James's, S.W.1. Tues., Mar. 8, 7 p.m.

Institution of Sanitary Engineers

LONDON
"Corrosion-Resisting Materials in Plumbing and Drainage at Chemical Works," by R. T. Gillet. Caxton Hall, S.W.1. Thurs., Mar. 10, 6 p.m.

Junior Institution of Engineers

LONDON
"Rolling of Structural Sections," by W. H. Bailey. Fri., Mar. 11, 7 p.m.

Newcomen Society

LONDON
"Hand-Wrought Chains," by W. K. V. Gale; and "The Vertical Winding Engines of Durham," by G. M. Watkins. Wed., Mar. 9, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"A Comparison of the Total Weight and Bulk of In-Line Naval Gas-Turbine Engines of Differing Degrees of Complexity," by D. F. Collins and D. W. Thomas. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., Mar. 11, 6.15 p.m.

Royal Aeronautical Society

PRESTON
"Structural Safety," by Professor A. G. Pugsley. Preston Branch. Bull and Royal Hotel, Preston. Thurs., Mar. 10, 7 p.m.

Royal Meteorological Society

LONDON
"Clouds," by F. H. Ludlam. County Hall, Westminster Bridge-road, S.E.1. Thurs., Mar. 10, 5.30 p.m.

Royal United Service Institution

LONDON
"Long-Distance High-Speed Flying," by Wing Commander L. M. Hodges. Wed., Mar. 9, 3 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Discussion on "Open-Hearth Furnaces: Checkers." B.I.S.R.A. Laboratories (Sheffield Group), Hoyle-street, Sheffield. Tues., Mar. 8, 7. p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal United Service Institution, Whitehall, London, S.W.1. (WHItehall 5854.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield 7. (Sheffield 53674.)